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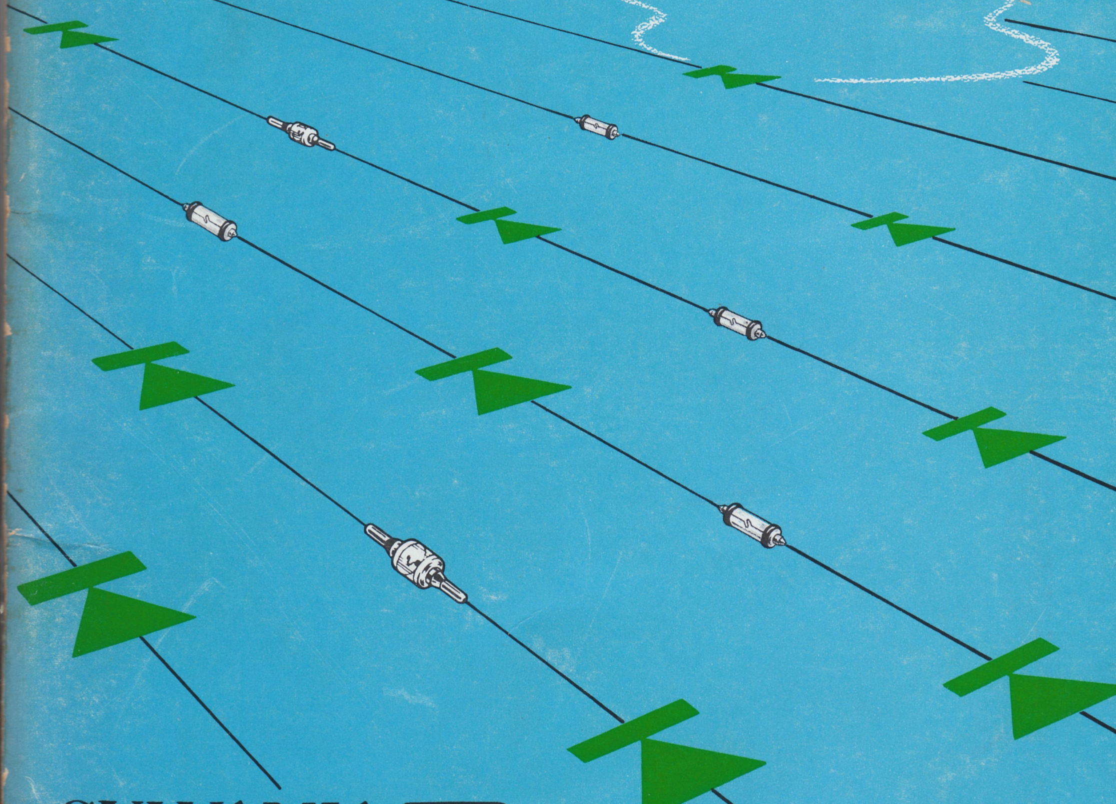
Industrial Uses

FOR GERMANIUM CRYSTALS



SYLVANIA

SYLVANIA ELECTRIC PRODUCTS INC.

Industrial Uses for Germanium Crystals

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INTRODUCTION

Our previous booklets on germanium crystal applications have stressed the use of the crystal in communications and experimental work for the radio hobbyist. From time to time, many of the schemes described in these booklets have been adapted to industrial use with good results.

Realizing that there are many applications of germanium crystals which are of particular use to industry and of only secondary interest to the communications workers who were the first to benefit by introduction of semiconductor devices, we have devoted this booklet entirely to industrial applications.

It has been rather difficult to make a selection from the numerous applications which were either devised by us or suggested by others. In order to arrive at a conclusion, we talked with plant engineers, industrial engineers, and consultants; we tested and screened applications, and then screened again. The final result is in the material presented herein. We feel that each application offered will introduce the useful germanium crystal to some of our most exacting users — the men who keep the wheels of industry turning.

No license is to be implied with respect to any inventions described herein, and no responsibility is assumed for the application or interpretation of the information contained herein, or for any infringement of patent or other rights of third parties which may result from the use of that information.

We hope that this booklet will be widely and well read and that it, like its predecessors, will be valued for its usefulness.

Sylvania Electric Products Inc.

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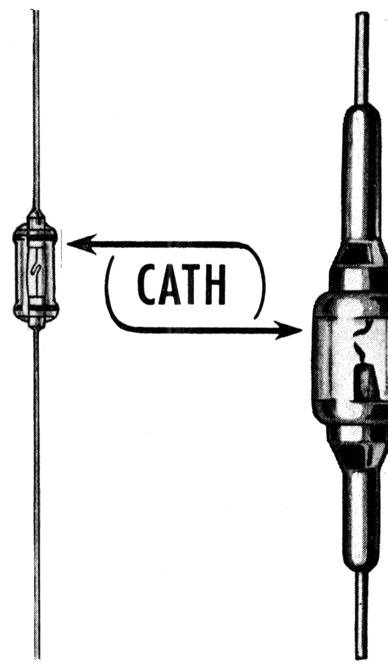
FIGURE

On each of the larger Sylvania Germanium Diodes this graphic symbol is so located as to indicate the cathode lead. On each miniature diode the location of the color bands is adjacent to the cathode lead.



CHAPTER 1

Relays and Relays Applications

1.1 Polarity-Sensitive DC Relay.

The high back-to-front resistance ratio of a germanium crystal may be used to give a low-current DC relay a sense of polarity. Figure 1-1 shows the simple circuit.

The relay and diode are connected in series with the DC input terminals. When terminal 1 is positive, high current flows through the crystal which is forward-connected for this polarity, and the relay is actuated. When terminal 1 is negative, the high back resistance of the crystal (which is reverse-connected for this polarity)

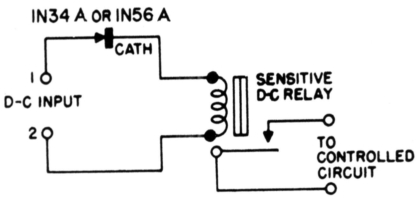
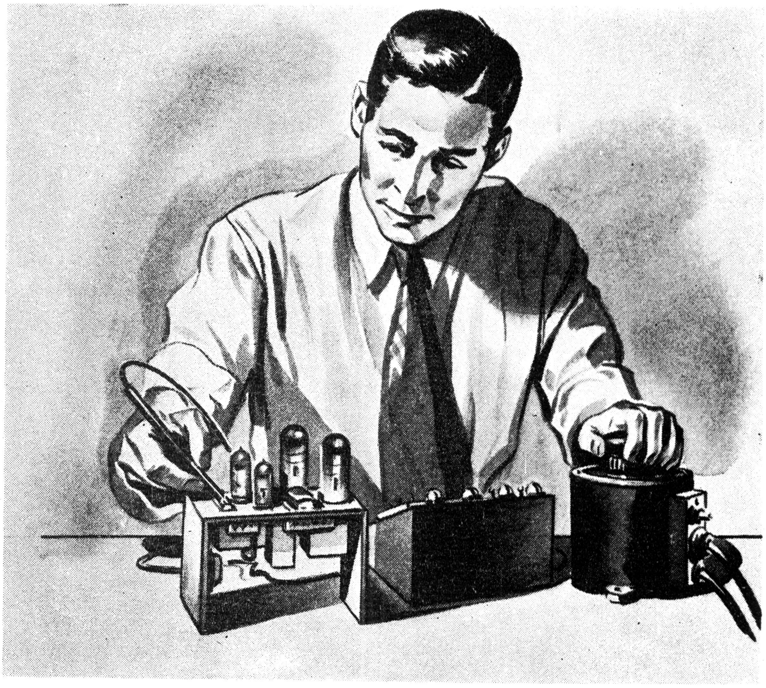


Fig. 1-1

allows only a minute current to flow and the relay cannot operate. Reversing the crystal permits the relay to operate when terminal 1 is negative.

Crystal type 1N34A is recommended for relay coil currents up to 50 ma., and 1N56A for 60 ma. Higher currents can be handled by parallel-connecting additional crystals as required. For high-voltage operation, a sufficient number of crystals may be connected in series, in place of the single crystal shown.



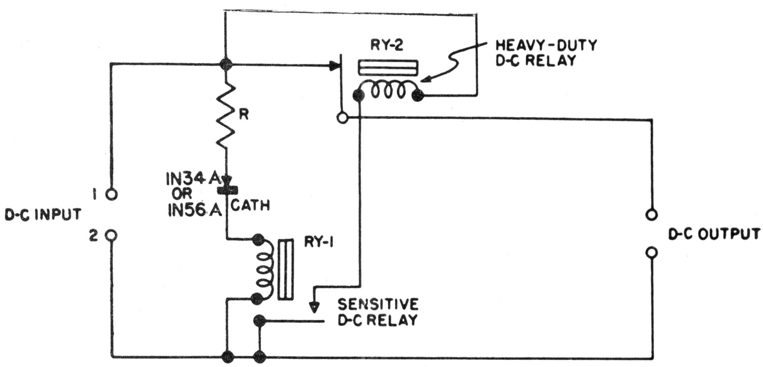


Fig. 1-2

1.2 Protection Relay for DC Lines.

Some DC devices operate in reverse, fail to operate, or are damaged by accidental reversal of the DC line polarity. Examples are DC motors, polarized relays, electron tubes, electroplaters, and batteries on charge. A crystal-controlled polarity-sensitive relay system can be used to protect such devices by removing the voltage automatically in case of line polarity reversal.

Figure 1-2 shows the circuit of a protective system. The crystal is connected in series with the coil of a sensitive, normally-open DC relay (RY-1) and enough series resistance R (if needed) to limit the crystal and relay current to a safe value. Relay RY-1 operates on a few milliamperes. The DC is connected from the INPUT to OUTPUT terminals through the normally-closed contacts of a heavy-duty DC relay, RY-2. The coil of this latter relay is designed to operate directly from the DC supply voltage.

Input terminal 1 normally is negative. At this polarity, the germanium crystal is reverse-connected and appears as a high resistance in series with relay RY-1. This high resistance prevents relay RY-1 from picking up. Relay RY-2 accordingly is not actuated, and DC voltage appears at the OUTPUT terminals of the circuit.

If the line polarity is reversed, input terminal 1 is positive, the crystal conducts, and relay RY-1 closes. This, in turn, actuates the heavy-duty relay, RY-2, which opens the line and removes voltages from the OUTPUT terminals.

The coil of relay RY-1 must operate on not more than 50 ma. DC if a 1N34A crystal is used, or not more than 60 ma. for a 1N56A Crystals may be paralleled for higher current values. Relay RY-2 may be any convenient unit which will operate on the DC supply voltage and whose coil current can be handled safely by the contacts of RY-1.

1.3 Novel Lock-In Relay.

At high reverse voltages, germanium crystals have a "breakdown" characteristic. That is, the reverse current increases suddenly when the breakdown voltage is reached. This action is somewhat analogous

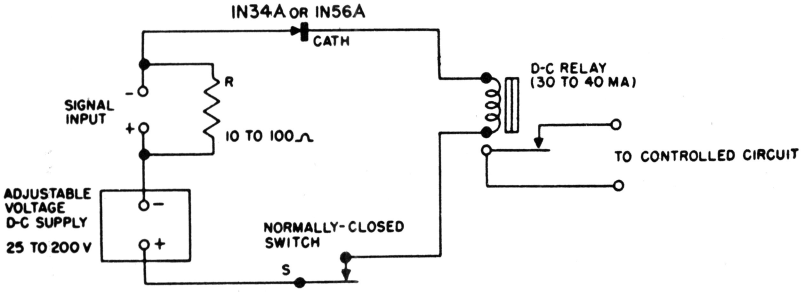


Fig. 1-3

to the breakdown of a neon bulb or other gaseous tube. Momentary interruption of the voltage or reduction to a lower value in some cases will restore normal current flow. The voltage at which breakdown occurs is somewhat more negative than the value listed in crystal tables under the heading "Reverse Voltage for Zero Dynamic Resistance," but is approximately –75 for the 1N34A and –50 for the 1N56A.

A unique application of this breakdown phenomenon is a simple lock-in DC relay which will pick up on the application of a small pulse of AC or DC and will remain closed, after the pulse has passed, until the circuit is interrupted momentarily.

Figure 1-3 shows the circuit for accomplishing this action. The DC supply voltage is adjusted to a value slightly under that required for crystal breakdown. This may be done with the aid of a 0-100 DC milliameter inserted temporarily between the relay coil and the cathode of the crystal. At breakdown, the meter deflection will jump abruptly to a high value. The crystal must be operated as close as possible to the breakdown point without a spontaneous occurrence of breakdown. A small voltage (either AC or DC with the polarity shown in Figure 1-3) then applied momentarily at the SIGNAL INPUT terminals, across resistor R, will trigger the crystal and pick up the relay. High current then will continue to flow, keeping the relay closed, until switch S momentarily is opened.

The magnitude of signal voltage which will trigger the circuit into operation depends upon individual crystal characteristics and upon the resistance of the relay coil. It will be between 10 and 15 volts (DC or peak AC) for the 1N34A or 1N56A, becoming lower as the crystal temperature increases from prolonged or closely-repeated operation.

This circuit is intended for intermittent operation only, since operation of the crystal beyond the breakdown voltage level produces internal heating. The crystal characteristic has a reverse bend at break down; consequently the circuit should contain a minimum amount of protective resistance.

1.4 Wide-Band AC Relay.

The addition of a germanium crystal rectifier to a milliampere-type DC relay converts the latter into a dependable AC relay capable of

operating over a wide frequency range including power-line, supersonic, ultrasonic, and radio frequencies.

The efficiency of the circuit is increased by connecting a second crystal, D_2, (See Figure 1-4) in the reverse direction across the relay coil. On positive half-cycles of applied signal voltage (input terminal 1 positive), the upper crystal, D_1, conducts and energizes the relay coil. Crystal D_2, being reverse-connected, offers high resistance and does not detract appreciably from the relay current. When input terminal 2 goes positive, crystal D_2 then is forward-connected and, since it offers a low-resistance path, conducts around the relay and D_1.

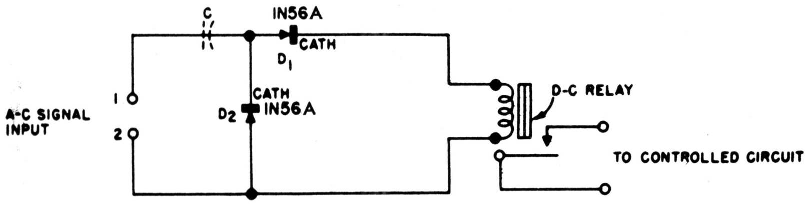


Fig. 1-4

If desired, a capacitor, C, may be added to block any DC component in the circuit, thereby preventing damage to the crystals and relay. Suggested values of capacitance are 0.25 to 1 ufd. for frequencies from 50 to 5000 cycles, 0.02 to 0.05 ufd. for 5000 to 20,000 cycles, 0.01 ufd. for 20 to 500 kc., 0.001 ufd. for 500 kc. to 2 Mc., and 100 ufd. for frequencies higher than 2 megacycles.

With type 1N56A crystals, a maximum delay current of 60 ma. DC can be handled. For higher currents, two or more 1N56A's may be connected in parallel in place of each of the single crystal, D_1 and D_2. AC voltages as high as 1000 volts r.m.s. can be handled if an appropriate series resistor is connected between input terminal 1 (or capacitor C) and crystal D_1.

1.5 Coil Protector for Sensitive DC Relay.

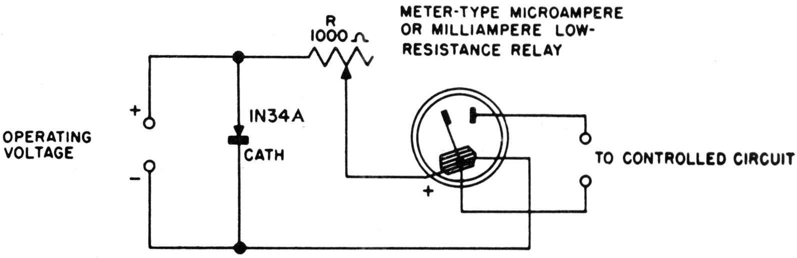


Fig. 1-5

Coil burnout is a serious problem when using microampere-type DC relays in industrial equipment where the relay coil resistance must be low and in which the applied voltage may rise unexpectedly to excessive levels. Germanium crystals in compressor circuits have been used to protect sensitive DC milliammeters and microammeters under similar conditions and can be used also for relay protection.

Figure 1-5 shows a crystal compressor circuit for relay coil protection. Current through the crystal increases non-linearly at a rapid rate as the DC operating voltage increases, and is several times the relay current. At higher voltages, more current thus flows through the crystal than through the relay. The result is a tapering-off of the relay current after the applied voltage reaches and exceeds a value determined by the experimental setting of rheostat R.

Because of the added resistance of the rheostat, a higher voltage than ordinary will be required to close the relay. Also, because of the crystal current, a higher current level is required by the circuit than by the relay if used alone. However, in many cases this will cause little or no inconvenience. It is not advisable to allow more than 50 ma. to flow through the crystal if it is a 1N34A, 38A, 54A, 55A, 58A, or 60; or more than 60 ma. if it is a 1N56A. Two or more crystals may be connected in parallel for higher currents or in series for higher applied voltages.

1.6 Selective DC Relay System.

Occasionally, it is desired to operate a series of relays, each connected at a different station across a common DC line, and to have each relay operate only when the bus voltage reaches a predetermined value. This scheme is unsuccessful with conventional relays, since the lower-voltage will receive excessive voltage when the higher-voltage units are operated.

Germanium crystal limiting circuits may be employed to hold each relay voltage constant at a predetermined value. The scheme is illustrated by Figure 1-6 which shows two stations only but which may be applied to as many more as desired. This scheme is satisfactory only for use with high-resistance relays, since heavy current loading will destroy the regulating action of the circuits.

Assume that terminals A and B supply a low-voltage relay, and terminals C and D a high-voltage relay. As the control voltage is increased, A and B will deliver voltage up to a level corresponding to the local voltage e_1. This will be the pickup voltage of the low-voltage relay. As the control voltage increases beyond this point, the voltage at A and B will remain constant, thus protecting the relay or other equipment connected to the terminals. Terminals C and D also will deliver a voltage which will level off to a constant value as the control voltage exceeds the local voltage e_2. The pickup voltage of the high-voltage relay corresponds to e_2.

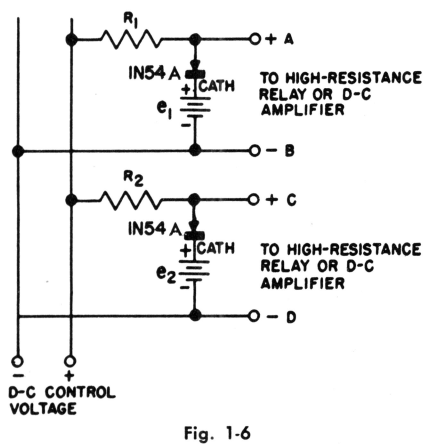


Fig. 1-6

By proper choice of voltage e_1 and e_2 and of series resistors R_1 and R_2, each relay will pick up at a given level of the control voltage and will continue to hold without an increase in current until the control voltage falls below that value. Voltages e_1 and e_2 can be supplied by a small rectifier system, although batteries are shown for simplicity in the circuit diagram.

The high resistance of the crystals in the reverse direction prevents discharge of the local voltage sources back into the DC line.

1.7 Proportional Hold-In, Drop-Out Relay.

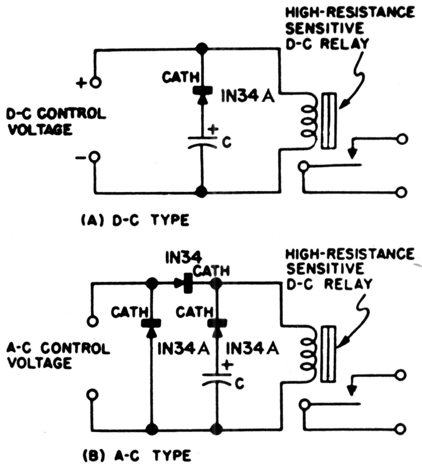


Fig. 1-7

Figure 1-7 shows two interesting circuits for relays with delayed dropout, the delay time being proportional to the length of time the relay was held in. When the control voltage is applied only momentarily, the relay will pick up and drop out quickly; but when the relay has been held in for a considerable time, it will drop out only after a proportionate interval.

In Figure 1-7 (A), when the control voltage is applied the relay will be picked up immediately but capacitor C cannot charge

instantaneously because the reverse-connected crystal acts as a high resistance limiting the charging current. The voltage must be sustained over an appreciable interval in order to charge the capacitor to the full value of the control potential. When the control voltage is interrupted, current then will flow from the capacitor through the low forward resistance of the crystal and will continue to hold in the relay until the charge has been dissipated or sufficiently reduced to drop out the relay. If the voltage was not applied for a long enough interval to charge the capacitor, the relay will drop out immediately upon interruption of the voltage, or shortly thereafter.

The circuit of Figure 1-7 (B) is similar, except that two additional crystals have been provided as rectifiers for an AC control voltage.

The capacitances may be chosen experimentally, with a capacitor decade or substitution box, to give desired timing intervals in conjunction with the relay coil resistance and operating voltage available. Best results will be obtained with sensitive (milliampere-type) DC relays having high coil resistances, since these units have low current requirements and can be held in successfully by capacitor discharge currents.

1.8 "Wave-Front" Relay.

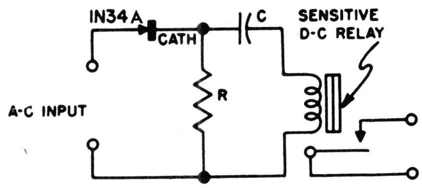


Fig. 1-8

When an AC voltage is applied to the INPUT terminals of the circuit shown in Figure 1-8, the crystal conducts and a DC voltage is developed across resistor R. This DC voltage charges capacitor C through the coil of the sensitive DC relay. Capacitor charging current flowing through the coil actuates the relay. But the capacitor

becomes fully charged and then current ceases to flow. The relay accordingly drops out and remains open although the AC voltage may still be present at the INPUT terminals. Further closures of the relay may be accomplished only by interrupting and re-applying the AC or by raising the AC voltage appreciably.

The result of this action is that the relay closes momentarily when a constant AC voltage first is applied. It then opens and remains open (although the AC signal is maintained) unless the signal is thrown off and on. Because the start of an AC signal, or wave train, actuates the relay, the name *wave-front* relay seems appropriate.

Resistance R must have a value such that capacitor C can discharge through it quickly when the AC has been removed. The speed at which the relay closes depends upon the time constant determined by capacitance C and the relay coil resistance. Suggested values are R = 100 ohms and C = 1 microfarad for a 9000-ohm coil (1-milliampere DC relay). The applied signal would be of the order of 12 volts r.m.s at frequencies of 60 cycles to 10 Mc. For 60 cycle input, a 2 microfarad condenser will probably improve operation.

1.9 Transient-Operated Lock-In Relay.

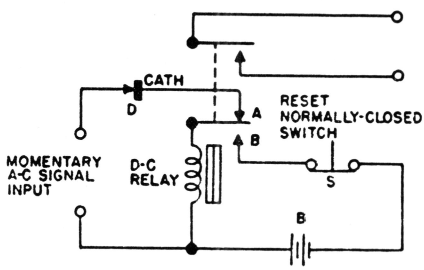


Fig. 1-9

Figure 1-9 shows a circuit in which a relay will lock-in in response to a signal applied momentarily to the input terminals of the circuit,

and will remain locked in, although the original signal has ceased, until the local circuit momentarily is interrupted. In this manner of operation, the circuit is analogous to that of a thyratron tube.

Operation of the circuit is simple: An AC signal is rectified by crystal D and the resulting direct current actuates the relay. The relay armature moves from contact A, opening the signal circuit, and reaches contact B. This closes the local circuit from the battery or DC power supply (B) through the relay coil. This local source then will continue to hold the relay closed (and disconnected from the signal circuit) until it is interrupted by the RESET switch, S. In order to prevent buzzer action, contact B must be set close enough to the armature that positive contact will be made quickly after the armature leaves contact A.

A number of these relay circuits may be cascaded for counting purposes. The basic circuit is useful also for removing power to protect critical equipment at the first appearance of dangerous surges. Another use is to short circuit the input terminals of sensitive industrial recording equipment to protect the latter from damaging signal levels.

1.10 Simple Spark Suppressor for Relay Contacts.

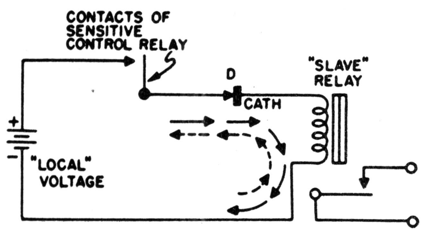


Fig. 1-10

Numerous schemes have been worked out for using the unilateral conductivity of sensitive relays. Figure 1-10 shows an extremely

simple version involving merely the connection of a crystal D, in series (with proper polarity) with the contacts of a sensitive relay and the coil of a slave-relay.

When the contacts close, direct current flows through the crystal and slave-relay coil in the direction of the solid arrows. The crystal resistance is low in this direction. When the contacts of the control relay open, the collapsing magnetic field of the slave-relay coil generates a high-voltage counter e.m.f. which causes a current to flow in the direction of the dotted arrows. This high voltage ordinarily would cause severe sparking at the contacts of the control relay. But with the crystal in the circuit, the reverse current encounters the high back resistance of the crystal and therefore is limited.

The relay circuit should be checked first without the crystal to determine the peak value of the counter e.m.f. generated with the relay contacts open. This may be done with a voltage-calibrated oscilloscope. The proper crystal type then to use is one which has a reverse operating voltage rating equal to, or higher than the measured peak voltage. If the peak voltage exceeds the rating of any type, several crystals may be connected in series to obtain the required voltage rating.

In some cases the series circuit has proven more effective and given longer crystal life than the more common method of connecting a crystal in parallel with the slave-relay coil.

The presence of one or more crystals in the circuit may require that the "local" DC voltage be raised slightly above normal for the slave relay, in order to overcome the small crystal forward resistance.

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1.11 Spark Suppressor for Inductive-Load Relay.

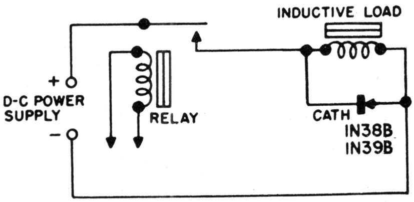


Fig. 1-11

Relay contacts are subject to severe sparking and wear when switching inductive loads. Such loads include motors, solenoids, contactors, heavier-duty relays, locks, valves, etc.

The sparking can be reduced by reverse-connecting a high-back-voltage crystal such as 1N38B or 1N39B across the inductive load, as shown in Figure 1-11. When the inductive device is operating, current flow through the crystal is small because of the high-back resistance. When the relay opens, however, the counter e.m.f. generated by the collapsing magnetic field in the inductance is of opposite polarity, and the resulting energy is dissipated in the low forward resistance of the crystal, instead of sparking across the opening relay contacts.

In the past, crystals often have been connected in this way across industrial relay coils, but it is not generally known that the same connection can be used successfully with motors and other heavier-duty magnetic equipment.

The peak value of the counter e.m.f. should be checked with a voltage-calibrated oscilloscope before installing the crystal. If this voltage exceeds the rated continuous reverse working voltage of a single crystal of any type, the proper number of crystals should be connected in series to handle this peak counter e.m.f. without breakdown.

1.12 Remote Carrier-Current-Controlled Relay.

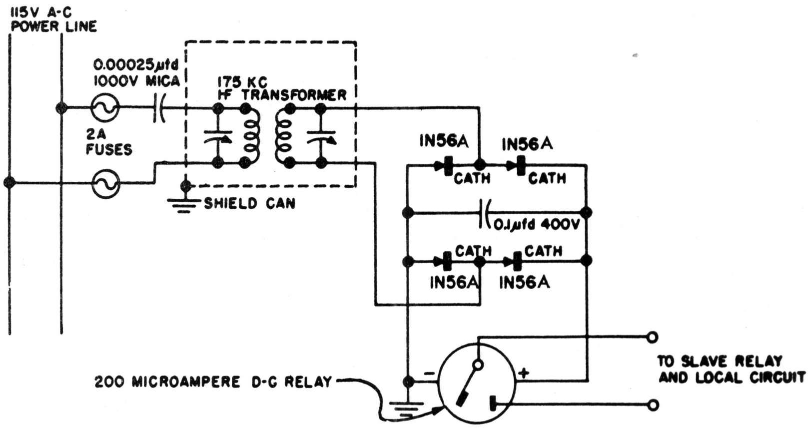


Fig. 1-12

A simple relay-receiver for remote control operations performed over the AC power line is shown in Figure 1-12. This unit operates on an r.f. carrier frequency of 175 kc. and can be actuated over several hundred feet of power line by means of a small 5- or 10-watt-output 175-kc. oscillator coupled into the power line.

The tuning unit is a 175-kc. i.f. transformer peaked to the operating frequency. The primary is coupled to the power line through a 0.00025-ufd. 1000-volt mica capacitor which offers high impedance to the power frequency and thus allows the receiver to be connected continuously to the line.

The detector consists of four 1N56A high-conduction crystals connected in a full-wave bridge circuit. DC output from the bridge actuates a 200-microampere DC relay which, in turn, operates a heavy-duty slave relay for the control of any desired machine or device.

Possible applications are the control of remotely-located motors, switches, signals, lights, locks, doors, and similar devices. Use of the available power line makes it unnecessary to run special wires.

CHAPTER 2

Timing Circuits

2.1 Delayed-Make Circuit.

In the circuit shown in Figure 2-1, a DC voltage appears across the load at some instant after switch S is closed. The delay interval is governed by the time constant of resistor R_1 and capacitor C.

When switch S is closed, point B receives a constant positive potential equal to one-half of the DC supply voltage. Point A, however, initially is at zero potential, since capacitor C cannot charge immediately. As the capacitor charges through resistor R_1, the potential at point B and the 1N34A anode grows more positive. But

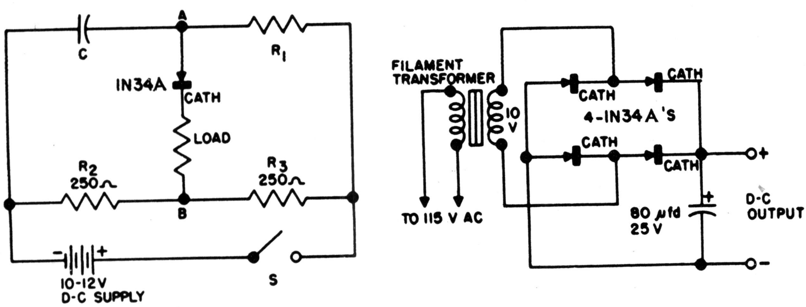
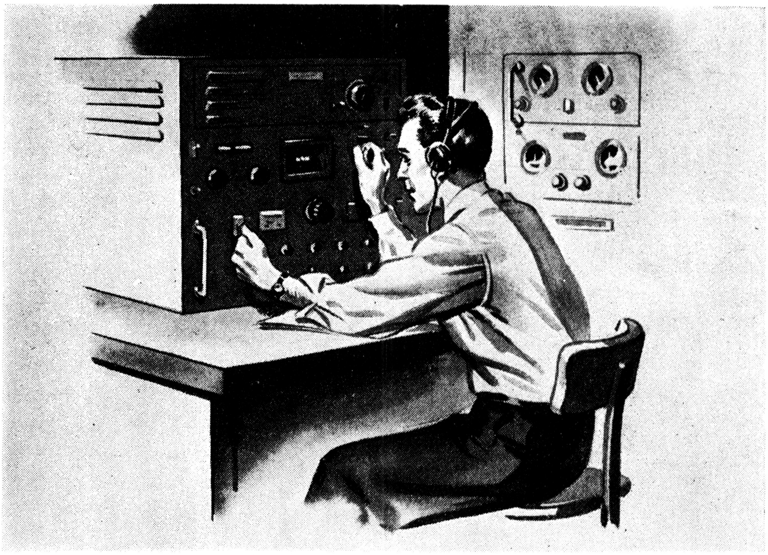


Fig. 2-1

since the 1N34A cathode is more positive than the anode, no current can flow through the crystal into the load. When the capacitor becomes fully charged, point A will be more positive than point B, and the crystal will conduct. The load then will be activated. At the instant that the positive potential at A exceeds that at B, the crystal quickly switches current into the load. The rapidity of operation is one advantage of this circuit.



The values of C and R_1 are chosen for the desired delay time. A rheostat may be used at R_1 when adjustment of the timing rate is desired. In order to allow ample current flow through the load, it is preferable to choose R_1 low and C high in value for a given time constant.

The load device may be a low-current DC relay, or a load resistor across which a potential is developed for presentation to an industrial DC amplifier system.

If operation from the AC power line is desired, a miniature power supply may be constructed with a filament transformer, germanium crystal bridge rectifier, and electrolytic capacitor (as shown also in Figure 2-1) and substituted for the battery.

2.2 Crystal as Timing Resistor.

In most R-C-type electronic timers, the adjustable resistor setting the timing rate is a high-resistance potentiometer. The high value of resistance required in this application makes necessary the use of a composition-type of rheostat or potentiometer, and this type usually is not stable nor does it hold its calibration over long periods.

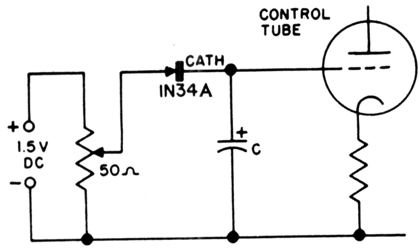


Fig. 2-2

In the timer circuit shown in Figure 2-2, the resistance component of the timing circuit is a 1N34A crystal. The forward resistance of the crystal varies over wide limits with applied voltage. If the voltage is varied between 0.1 and 1.5 v., a small 50-ohm wirewound potentiometer may be used for the calibrated timing control. A wirewound control enhances accuracy and stability.

When the potentiometer is set for 0.1 volt, the resistance of the crystal is approximately 4000 ohms. At 1.5 volts applied, the crystal resistance is about 100 ohms. This is a resistance range of 40 to 1. The timing interval is governed by the time constant of the crystal resistance and the capacitance C. This is a delayed-make type of time delay circuit.

The DC voltage across the fully-charged capacitor, C, varies with the setting of the potentiometer. The relay or other load device in the plate circuit of the tube, and the circuit constants, accordingly must be chosen for operation at the lowest voltage which will appear across the capacitor at full charge. This will insure that operation will be obtained at all settings of the timing potentiometer.

2.3 Timing Marker Generator.

It is of value to use timing waves for reference in the recording of industrial data. The timing-wave pattern is recorded parallel to the data trace. When no timing system is provided internally by the recording equipment, it is convenient to record an AC signal of accurately-known frequency for this purpose. In this way, a reference time base is established. This technique is employed with industrial oscilloscopes and oscillographs and other direct-writing recorders. Occasionally, a reasonable sharp pulse with a known repetition rate is preferred to a sine wave for timing purposes, but suitable pulse generating equipment can be both complicated and costly. Figure 2-3 show a simple arrangement for deriving timing pulses from a sine wave signal.

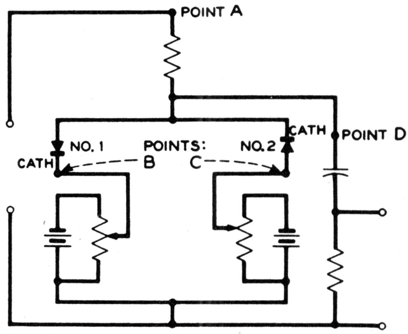


Fig. 2-3(A)

In this circuit, a 1N54A duo-diode is used as a biased rectifier. The bias is supplied by batteries providing voltages as determined by the desired operating point which can be any convenient voltage within the peak back voltage rating of the crystal (Figure 2-3 (B)).

The AC signal may be obtained from an audio oscillator or from the power line, depending on frequency requirements. The output is a sharp pulse, either positive or negative in direction, whenever the input voltage passes a point determined by the battery voltages.

The voltage waveforms at Point D, with different components disconnected are as follows; assuming sine wave input, and battery polarities as shown in Figure 2-3 (A):

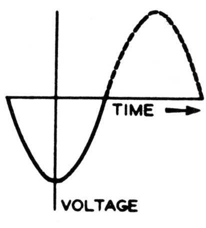


Fig. 2-3(B)

1. Crystal #2 Disconnected (A)
2. Crystal #1 Disconnected (B)
3. Both Crystals Connccted (C)

A

B

C

D

The output, with both diodes connected is shown at D

Using these circuit components, it is possible to make the quantity $V_A = V_B$ less than 0.1V.

Crystal 1)
Crystal 2) 1N35

$R = 56K$

$R_D = 5.6K$

$C_D = 300$ f

The circuit operation is as follows, assuming that an indication is desired at some point where the input signal is negative.

Crystal #1, biased in the conducting direction, will conduct during the period when point A is more positive than point B.

Crystal #2, biased in the back direction, will conduct during the period when point A is more negative than point C.

Thus, during a finite period of time, based upon V_A - V_B, neither crystal will be in conduction, and a sudden voltage change is evident across C_D and R_D. After differentiation, the output is available as a pulse of considerable magnitude whenever the input voltage goes through the level determined by V_A and V_B. It is also possible to get a recognizable output when V_A is made equal to V_B. This is due to the fact that when the voltage applied to the crystals is going through zero, the crystals exhibit an extremely high resistance in both forward and back directions. This, in effect, causes a period of non-conduction across both crystals, and a voltage change at point D. The output magnitude will be somewhat smaller in this case, for the output is dependent upon the voltage change at point D, and in turn upon V_A - V_B.

2.4 Discharge Stretcher for R-C Timing Circuits.

Resistance-capacitance combinations are widely used in electronic timing circuits. In these arrangements, a capacitor is charged from a DC voltage and then allowed to discharge through a resistor. The circuit remains in operation until the capacitor has discharged completely or until the capacitor voltage has fallen to some critical value. The capacitor voltage is applied to a high-impedance load, such as the grid-cathode circuit of a vacuum tube.

In some applications, particularly those involving multiple timing operations, it is desirable that the capacitor should not discharge completely between operations, but should retain some of its voltage below the deactivation point of the circuit. The residual voltage reduces the time interval necessary to re-start the circuit by again energizing the capacitor.

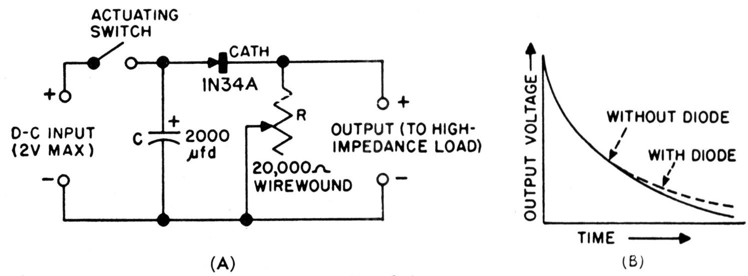


Fig. 2-4

The discharge interval may be stretched by the simple expedient of connecting a 1N34A crystal in series with the C and R elements of the timing combination, as shown in Figure 2-4(A).

Operation of the circuit is based upon the non-linear rate at which the crystal forward resistance varies with applied voltage, this resistance being highest at low voltages. When capacitor C is fully charged (1 to 2 volts), the crystal resistance is negligible compared to the resistance of the timing control, R. As the capacitor discharge voltage falls, the crystal resistance increases, becoming appreciable with respect to the control resistance, thereby increasing the time required for the capacitor voltage to fall to a given low value. The curve in Figure 2-4(B) shows approximately how the decay of output voltage is prolonged by the crystal.

2.5 AC-Operated Slow-Release Timing Circuit.

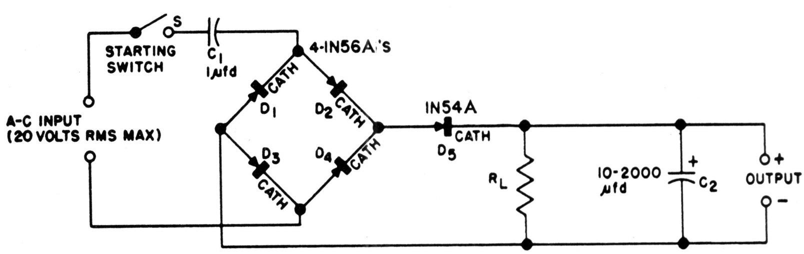


Fig. 2-5

Crystals are used both for rectifying and blocking in the AC-operated timing circuit shown in Figure 2-5. This circuit will be attractive in applications where only AC is available for operation.

When the starting switch, S, is closed, the four bridged-connected 1N56A crystals (D_1 to D_4) deliver a DC voltage to the R-C timing circuit ($R_L C_2$) through the forward-connected 1N54A series crystal, D_5. Capacitor C_2 is charged by this voltage which appears also across the OUTPUT terminals.

When switch S is opened, capacitor C_2 then discharges through resistor R_L at a rate determined by the time constant of the R-C combination. Since crystal D_5 is reverse-connected with respect to the capacitor voltage, any leakage path back toward the input half of the circuit is of very high resistance. Furthermore, both halves of the bridge rectifier also are reverse-connected with respect to this polarity of voltage. The result is that most of the discharge current flows through resistor R_L.

The discharge resistor, R_L, may be chosen with respect to capacitance C_2 to give the desired timing interval. For direct operation R_L may be the high-resistance coil of a sensitive DC relay.

When R_L is a resistor (fixed or variable), the output terminals of the circuit may be connected to a high-impedance system such as an industrial DC amplifier input.

GERMANIUM DIODE INSTALLATION HINTS

1. Use the type of diode specified in the circuit diagrams. These types have been selected carefully to withstand circuit voltages and other operating conditions.

2. When soldering the diode into the circuit, hold the pigtail leads with a pair of long-nosed pliers. This will prevent heat from the soldering iron from entering and possibly damaging the crystal unit.

3. In all installations, use as much of the pigtail lead length as possible.

4. While the Germanium Diode is a rugged component, the user is cautioned against deliberately dropping the diode to the floor, tapping on it, or otherwise handling it in a rough manner so as to expose it unnecessarily to mechancial shock.

5. Mount the crystal diode so that it is reasonably free from severe mechanical vibration.

6. Keep the crystal diode as far as possible from heated objects.

7. Observe the diode polarity shown in the diagrams. The cathode terminal is plainly marked with the abbreviation "CATH" and with a wide band.

CHAPTER 3

Power Supply Applications

3.1 General Use of Crystals as Power Supply Rectifiers.

Within the limitations of its relatively low continuous forward current ratings, the germanium crystal offers several advantages as a simple power supply rectifier which merit consideration in designing and modifying low-voltage industrial equipment.

For a given current rating, the germanium crystal has less bulk and weight than many other "metallic" rectifiers. It also has the following additional advantages: (1) higher frequency response, (2) lower voltage drop, (3) higher operating efficiency, (4) lower self-capacitance, (5) less hysteresis, (6) better low-voltage operation, (7) closer matching between units, (8) lower internal heating, and (9) higher average ratio of permissible peak to average forward current.

Germanium crystals may be connected in series to withstand higher applied voltages, in parallel to pass higher currents than rated, and in series-parallel for both higher voltage and higher current. Series limiting resistors may be connected in series with these crystals, in the same manner as with other "metallic" rectifiers, to limit peak currents to safe values.

From the tables of ratings and characteristics, the two crystal characteristics which are of greatest interest in the selection of units for sine-wave power rectification are (a) average anode current and (b) continuous reverse working voltage. When a crystal is selected for its ability to supply safely the desired maximum DC output current, its continuous reverse working voltage also must be higher than the peak inverse voltage normally present in the power supply circuit. Only by meeting *both* of these requirements

will the crystal be a satisfactory choice. Thus, a 1N34A might be selected on the basis of ability to handle a desired output current level of 45 ma., but we note that its maximum continuous reverse working voltage rating is 60 v. and this would unsuit it for 45-ma. operation at *115 volts* (in a simple rectifier circuit without capacitors or inductors, the peak inverse voltage would be 163 volts). Neither would two 1N34A's in series be satisfactory. A single 1N39B, however, would suffice, since its maximum reverse voltage rating is 200 v.

In power supplies, germanium crystals may be employed in the conventional manner in half-wave, full-wave center-tapped, bridge, voltage multiplier, single-phase, and polyphase circuits.

3.2 100-MA. 115-Volt Rectifier Arrangement.

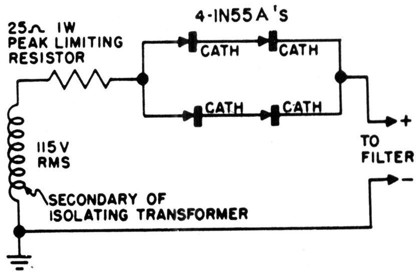


Fig. 3-1

Figure 3-1 shows how four 1N55A 150-volt crystals can be connected to provide all the advantages of the germanium rectifier in a half-wave power supply circuit delivering 100 milli-amperes DC Max. for an applied AC voltage or 115 r.m.s.

Because of the excellent frequency characteristics of the germanium crystal, this rectifier may be used at full efficiency and without derating in power supplies operated by high frequency generators, as well as at the common power-line frequencies.

Even with four crystals and a limiting resistor, the rectifier element will be small and may be mounted unobtrusively in existing equipment.

3.3 Low-Voltage AC Varistor.

Two closely-matched crystals can be connected as shown in Figure 3-2, to provide conduction on both halves of the AC cycle.

At low values of applied voltage (especially between 0.05 and 0.2 v.) the crystal conduction characteristic is quite non-linear. At

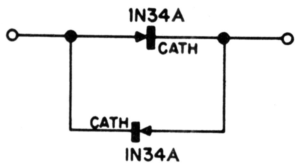


Fig. 3-2

these voltages the connection shown provides AC action similar to that obtained with thyrite resistors but at the low potentials and high frequency at which thyrite normally is not effective. In the pronounced non-linear region of the germanium crystal, a large change in crystal current is required to produce a small change in voltage drop across the crystal.

Various low-voltage devices (for operation between zero and 250 millivolts AC), in which thyrite may not be effective because of the low potentials involved, may be set up with the germanium varistor of Figure 3-2. These applications include millivolt AC voltage regulators, frequency multipliers, compressors, expanders, voltage-change multipliers, and constant current potentiometers found in literature on thyrite uses.

The non-linear conduction characteristic of the 2-crystal varistor, like the thyrite resistor used in many industrial applications, introduces appreciable odd-harmonic distortion. This fact must be considered when applying the device to power supply and other circuits.

3.4 Low-Voltage Limit of Crystal Rectifiers.

One of the chief advantages of the germanium crystal as a power supply rectifier is its performance at low AC voltages. Recent exhaustive tests by Sylvania physicists, however, set 1 millivolt peak as the minimum practical voltage which will be rectified satisfactorily.

At signal levels below 1 mv., the front-to-back current ratio deteriorates to the point that rectification ceases and the full AC cycle is passed with some loss.

The simple germanium crystal rectifier, in the absence of preceding AC amplification, therefore, is not recommended for use at applied voltages under 1 mv. peak. Sylvania silicon crystals are recommended at lower voltages.

3.5 General-Purpose Midget Variable Power Supply.

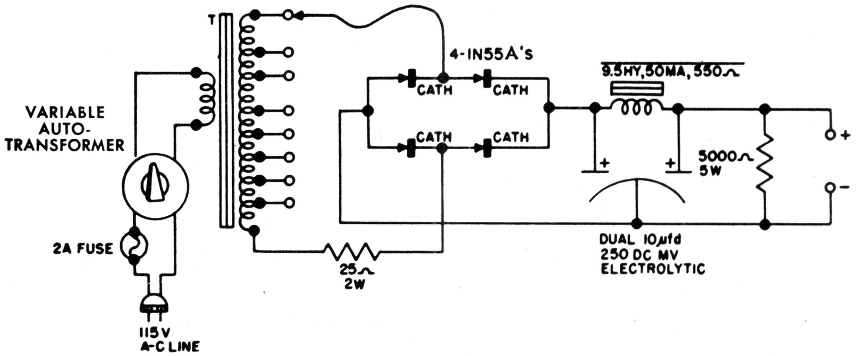


Fig. 3-3

A portable, AC-operated, variable output DC power supply is invaluable to the industrial technician as a substitution source and as a handy unit for supplying DC relays, timing equipment, light-sensitive apparatus, and similar gear during test or developmental work, as well as in trouble-shooting.

Figure 3-3 shows the circuit of a practical 50-ma. unit of this type which will supply full-load voltages as high as 117. This unit employs a 20-tap transformer which gives voltage steps of 1.1, 1.4, 1.5, 2.0, 2.5, 3.0, 5.0, 6.3, 7.0, 7.5, 12, 25, 30, 35, 50, 70, 85, 110, and 117. The DC output voltage is continuously variable in any step range by means of a primary Powerstat.

The rectifier is a full-wave bridge employing four 1N55A crystals. A 25-ohm, 2-watt resistor protects the crystals from excessive peak current.

This power supply offers the advantages of small size, light weight, easy portability, smooth output adjustment, and a wide selection of voltage ranges to suit a variety of industrial test demands. It will be useful in the industrial laboratory, as well as in the shop and on the assembly line.

CHAPTER 4

Applications to Industrial Instrumentation

4.1 DC-to-AC Converter Circuits.

Numerous industrial tests involve the measurement or amplification of small DC potentials of the order of millivolts. Thermocouple and strain gage output voltages are examples. The difficulties attendant to DC amplification have caused considerable attention to be given to the technique of converting the small DC voltages into proportionate AC voltage, amplifying the latter with a conventional AC amplifier, and then rectifying the amplified product back to DC. Several methods are in use for accomplishing the conversion. One employs a vibrator-type interrupter to chop the DC at a rapid rate.

Several schemes for DC-AC conversion are available in which germanium crystals accomplish the desired result through their modulating ability. All moving parts thus are dispensed with. Each of the circuits (Figure 4-1) is powered by a constant AC voltage, and delivers an AC output voltage which is proportional to the applied unknown DC voltage. The output voltage must be applied only to a high impedance (100,000 ohms or higher) which is the case when it is presented to the input of an AC amplifier.

In Figure 4-1(A), constancy of amplitude of the AC supply voltage is secured by using a square wave signal at a frequency of 400 to 500 cycles. The square wave is self-limited by its generator.

The conversion from DC to AC is accomplished by two 1N54A crystals. If no DC is applied to the DC INPUT terminals, crystal D_1 short circuits the negative half-cycle of the square wave, and crystal D_2 the positive half-cycle, with the result that no signal reaches the DC OUTPUT terminals. When a DC voltage is applied

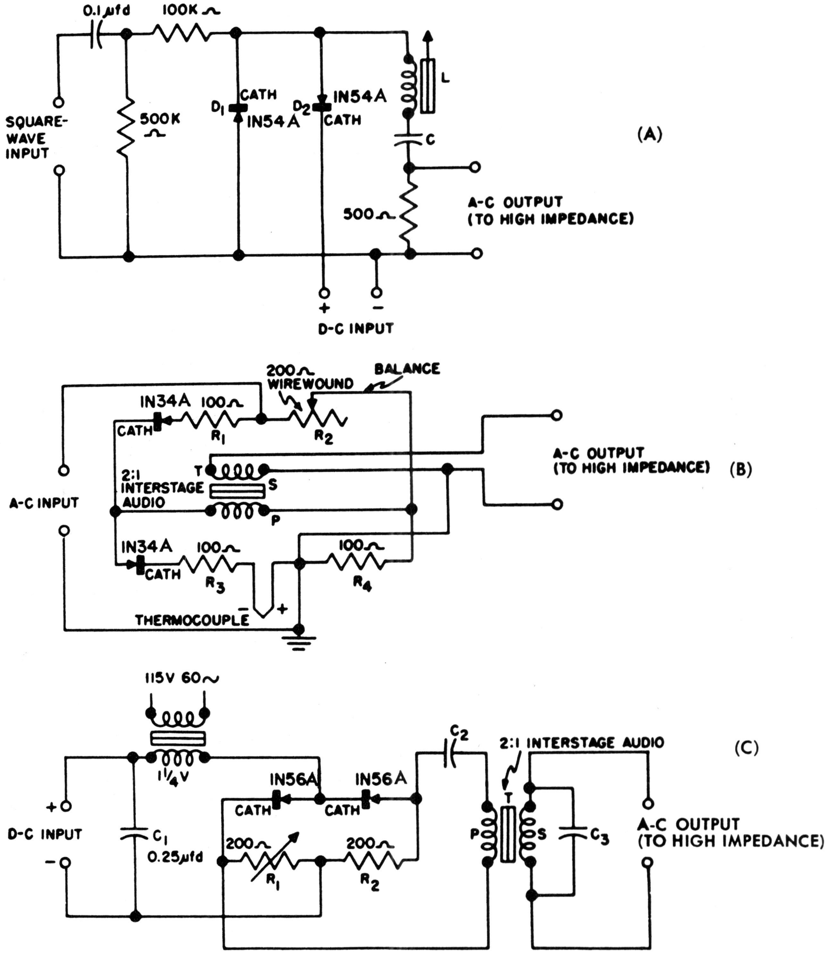


Fig. 4-1

to the DC INPUT terminals, it biases crystal D_2 and a proportionate part of the positive half-cycle of the square wave is transmitted. Thus, whenever DC is applied to the circuit, a square-wave positive half-cycle signal is transmitted through the filter, LC, to the AC OUTPUT terminals. The peak amplitude of the square-wave AC voltage applied to the AC INPUT terminals should be of the order of the maximum DC voltage to be handled.

The filter, LC, is adjusted to pass the frequency of the square-wave voltage, and the L and C values may be chosen accordingly.

This is a simple process, since the arrangement is a rudimentary series resonant circuit. By employing a tuneable choke at L, the filter may be adjusted closely to the pass frequency selected.

The circuit shown in Figure 4-1(B) was designed primarily to convert the weak DC output of a thermocouple into proportionate AC to be amplified by a conventional amplifier, but other DC signal sources may be used as well. The arrangement is a 4-arm bridge in which 1N34A crystals act as voltage-sensitive resistors in two arms.

A constant-amplitude sine-wave voltage is applied to the AC INPUT terminals. The BALANCE potentiometer, R_2, then is adjusted for zero AC output at room temperature. When subsequently the thermocouple temperature changes, the change in its generated DC voltage alters the resistance of the adjacent crystal, upsetting the bridge balance. A proportionate unbalance AC voltage consequently appears at the AC OUTPUT terminals. The maximum r.m.s. value of the AC input voltage will be of the order of 1 volt for most applications.

The circuit shown at Figure 4-1(C) is another 4-arm bridge with two 1N56A crystals acting as voltage-sensitive resistors in two arms, somewhat differently arranged from the preceding example. The AC and DC voltages are applied to the bridge in series with each other.

With the DC signal source connected to the DC INPUT terminals but delivering no voltage at the moment, the bridge is balanced for zero signal voltage at the AC OUTPUT terminals by adjusting the variable arm, R_1. When a DC signal subsequently is applied, the corresponding current flowing through the crystals will change the resistance of the latter and unbalance the bridge. An unbalance AC voltage, proportional to the applied DC, then appears at the AC OUTPUT terminals.

For improved output amplitude, both primary and secondary windings of the output transformer, T, are tuned to the frequency of the AC supply voltage. The primary of this transformer is tuned by capacitor C_2 with which it forms a series resonant circuit, and the secondary C_3 with which the latter winding forms a parallel resonant circuit.

4.2 Industrial R.F. Voltmeter.

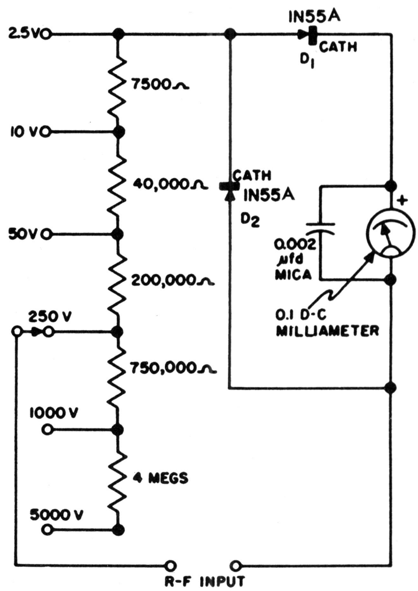


Fig. 4-2

High-powered radio-frequency generating apparatus is used in industry for dielectric heating, induction heating, soldering, hardening, etc.

An instrumentation problem usually arises when it becomes necessary to check performance of this equipment by measuring actual radio-frequency voltages. Ordinary AC voltmeters have serious errors at the frequencies involved and accordingly are unsatisfactory. AC vacuum-tube voltmeters have the necessary frequency response but are so sensitive that they are deflected erroneously and often are damaged by strong radio-frequency fields. A satisfactory solution is a non-electronic-type of AC voltmeter employing germanium crystals as meter rectifiers.

Figure 4-2 shows the simple circuit of such a meter. Using an inexpensive 0-1 DC millameter, and providing 100 ohms per volt sensitivity (which is adequate and foolproof for this application), six full-scale voltage ranges are provided: 0-2.5, 10, 50, 250, 1000 and 5000 volts r.f. The instrument can be used without frequency error from 50 cycles to approximately 40 Mc., and with varying amounts of negative error from 40 to 100 Mc. This adequately covers the radio frequencies employed in industry.

The meter rectifiers are two 1N55A crystals. On positive half-cycles of signal voltage, crystal D_1 conducts and deflects the milliammeter. On negative half-cycles, crystal D_2 conducts around the meter and D_1. If a DC component is present in the circuit under test, a 0.1-ufd. high-voltage capacitor may be connected in series with one of the R.F. INPUT terminals to protect the crystals and milliammeter. Due correction must be made at the test frequency for the presence of the capacitor in the circuit.

Since the crystal conduction curve is non-linear at low-current densities, an individual AC calibration must be made for this volt-

meter. The scale of the milliammeter cannot be used directly if highest accuracy is desired. The calibration can be made at the power line frequency if no higher-frequency source is available. The procedure consists of applying a series of accurately-known AC voltages to the R.F. INPUT terminals and noting the corresponding deflections of the milliammeter. A card or graph then may be drawn, or a special scale prepared for the meter. If precision resistors are used in the range switching circuit, accuracy in switching will be obtained. A special calibration will be necessary for the 2.5-volt range.

4.3 Replacing Germanium Crystals in Demodulators.

The same sensitive, reliable operation may be expected when germanium crystals are used in ring demodulators, phase comparators, and discriminators in industrial measuring equipment as in other applications of germanium crystals. Such circuits are employed in carrier-type equipment used with strain gages, accelerometers, displacement pickups, and similar transducers. Improved performance results from the long-term stability and lower dynamic impedance of the germanium crystal.

It is important to employ closely-matched crystals in these applications. Where two crystals are indicated, type 1N35 duo-crystal usually will suffice. Matched 1N56A's, obtainable on special order, are desirable where higher conductance is desired. Where four conventional crystals are indicated, Varistor Types 1N40 (plug-in) and 1N41 (lug-type) are satisfactory. Varistor Type 1N42 consists of four 100-volt crystals. Varistor 1N71 contains four high-conduction (low-impedance) crystals.

4.4 Improvised Low-Voltage D.C. Standard.

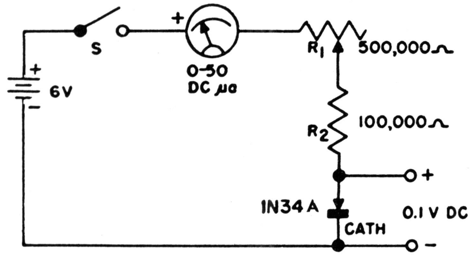


Fig. 4-3

The simple circuit in Figure 4-3 will supply a 0.1-volt DC potential to a high-impedance load or zero-current circuit for calibrations and other tests of the potentiometric type. In use, this circuit is similar to a standard cell.

Operation is based upon the non-linear forward conduction characteristic in the 1N34A at low current densities. With a series resistor, the crystal forms a voltage regulating (constant voltage) circuit. In this arrangement shown in Figure 4-3, for example, a voltage drop of 0.1 v. appears across the crystal when control R_1 is adjusted for a crystal current of approximately 20 microamperes, as indicated by the meter. If the 6-volt supply increased to 30 volts (5 times), the crystal voltage drop would rise only to a 0.2 v. With any normal small shift in the 6-volt supply, the change in crystal voltage drop would be so small as to be hardly detected. Resistor R_2 is a limiting resistor to prevent damage to the microammeter and crystal should control R_1 accidentally be advanced to zero resistance.

4.5 Signal Rectifier for Direct-Writing Graphic Recorder.

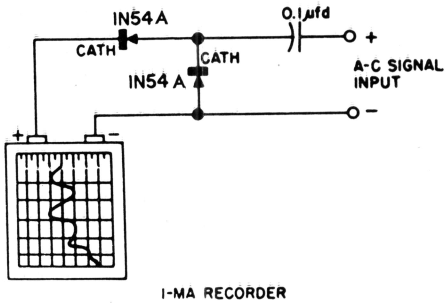


Fig. 4-4

Such instruments are widely used for the automatic recording of industrial data. Since this is a direct current instrument, however, only those impulses which can be transduced into DC may be used. Frequently, however, industrial signals are alternating and cannot be recorded directly with this instrument.

Figure 4-4 shows how two 1N54A crystals and a 0.1-ufd. capacitor can be connected ahead of the 1 ma. recorder to adapt it, when needed, to AC signals up to radio frequencies. Deflection of the recorder will be equal approximately to the average value of the AC component.

The simple adaptor can be removed easily when the recorder is to be used on DC. The shunt-connected second crystal in the circuit prevents flutter of the recording pen at low frequencies.

If the data to be recorded is a current component, a 100-ohm shunt resistor should be connected between the two AC SIGNAL INPUT terminals. For voltage recording, the shunt must be removed. In either case, a special calibration must be performed with recorder deflections plotted against known AC inputs, because of the non-linearity of the germanium crystal at current levels of 1 milliampere and less.

Sylvania Crystal Diodes

*ABSOLUTE MAXIMUM RATINGS AT 25°C:

Sylvania Crystal Diodes

CHARACTERISTICS AT 25°C:

Type	Application or Description	Temperature Range °C	Continuous Reverse Working Voltage (volts)	Recurrent Peak Anode Current (ma)	Average Anode Current (ma)	Surge Current (ma/1 sec. max.)	Peak Reverse Voltage for Zero Dynamic Resistance (volts min.)	Forward Current at +1 Volt (ma min.)	Reverse Current (ua max.)	Forward Resistance at +1 Volt (ohms max.)	Reverse Resistance (ohms min.)
5 — 1N34A	60 volt	—50 to +90	60	50	50	500	70	5	30 at —10v, 500 at —50	200	333K at —10v, 100K at —50v
1N35	Matched Pair (Note 1)	—50 to +75	50	60	22.5	100	70	7	10 at —10v	143	1 meg. at —10v
1N38A	100 volt	—50 to +90	100	150	50	500	120	4	6 at —3v, 500 at —100v	250	500K at —3v, 200K at —100v
1N38B	100 volt (Note 2)	—50 to +90	100	150	50	500	120	4 (25 max.)	6 at —3v, 500 at —100v	250	500K at —3v, 200K at —100v
1N39A	200 volt	—50 to +90	200	150	50	500	225	4	100 at —100v, 600 at —200v	250	1 meg. at —100, 333K at —200v
1N40	Plug-in Varistor (Note 3)	—50 to +75	25	60	22.5	100	70	12.7 at 1.5v	40 at —10v	120	250K at —10v
1N41	Packaged Varistor (Note 3)	—50 to +75	25	60	22.5	100	70	12.7 at 1.5v	40 at —10v	120	250K at —10v
1N42 43	100 volt Varistor (Note 3)	—50 to +75	100	60	22.5	100	120	12.7 at 1.5v	750 at —100v	120	133K at —100v
4 — 1N54A	High Back Resistance	—50 to +90	50	150	50	500	70	5	7 at —10v, 100 at —50v	200	1.4 meg. at —10v, 500K at —100v
1N55A	150 volt (Note 2)	—50 to +90	150	150	50	500	165	4	500 at —150v	250	300K at —150v
1N56A	High Conduction (Note 2)	—50 to +90	40	200	60	1000	50	15	300 at —30v	67	100K at —30v
1N58A	100 volt	—50 to +90	100	150	50	500	115	4	600 at —100v	250	167K at —100v
1N59A	250 volt	—50 to +90	250	150	50	500	270	4	600 at —250v	333	200K at —150v
1N60	Video Detector	—50 to +90	25	150	50	500	—	Note 5	Note 6	—	150K (Note 6)
				Note 4	Note 4						
1N63	High Back Resistance	—55 to +90	100	150	50	500	120	4	50 at —50v	250	1 meg. at —50v
1N65	70 volt	—55 to +90	70	150	50	500	80	2.5	200 at —50v	400	250K at —50v
3 — 1N67A	Miniature—High Back (Note 2)	—55 to +90	80	90	30	300	100	4	5 at —5v, 50 at —50v	250	1 meg. at —5v and —50v
5 — 1N69	60 volt	—55 to +90	60	125	40	400	75	5	5 at —10v, 850 at —50v	200	333K at —10v, 100K at —50v
1N69A	60 volt (Note 2)	—55 to +90	60	125	40	400	75	5 (25 max.)	30 at —10v, 500 at —50v	200	333K at —10v, 100K at —50v*
9 — 1N70	100 volt	—55 to +90	100	90	30	350	125	3	25 at —10v, 300 at —50v	333	400K at —10v, 167K at —50v
1N70A	100 volt (Note 2)	—55 to +90	100	90	30	350	125	3 (25 max.)	25 at —10v, 300 at —50v	333	400K at —10v, 167K at —50v
1N71 72	Low Impedance Varistor (Note 7)	—50 to +75	40	200	60	1000	50	15	300 at —30v	67	100K at —30v
2 — 1N77A	Photodiode	0 to +50	Note 8	—	—	—	Note 9	—	15 at —10v, 100 at —50v (Dark)	—	670K at —10v, 500K at —50v
1N81	Low Voltage	—55 to +90	40	90	30	350	50	3	10 at —10v	333	1 meg. at —10v
1N81A	Low Voltage (Note 2)	—55 to +90	40	90	30	350	50	3 (25 max.)	10 at —10v	333	1 meg. at —10v
1N82	UHF Mixer	—50 to +90	Note 10	—	—	—	—	Note 10	—	—	—
1N82A	UHF Mixer	—50 to +90	Note 10	—	—	—	—	Note 10	—	—	—
1N90	Miniature—General Purpose	—55 to +90	60	90	30	300	75	5	750 at —50v	200	67K at —50v
1N98	Miniature—High Back	—55 to +90	80	90	30	300	100	20	8 at —5v, 100 at —50v	500	62.5K at —5v, 500K at —50v
1N100	Miniature—High Back	—55 to +90	80	90	30	300	100	20	5 at —5v, 50 at —50v	500	1 meg. at —5v and —50v
1N111	60 volt Computer	—50 to +90	60	150	25	500	70	5	Note 11	200	400K (Note 11)
1N112	60 volt Computer	—50 to +90	60	150	25	500	70	5	Note 11	200	200K (Note 11)
1N113	60 volt Computer	—50 to +90	60	150	25	500	70	2.5	Note 11	400	400K (Note 11)
[illegible]	[illegible]	—50 to +90	60	150	25	500	70	2.5	Note 11	400	200K (Note 11)

1N120	60 volt—Computer	−50 to +90	60	150	25	500	70	5	Note 11 and Note 12	200	200K (Note 11)
1N126	Miniature—60 volt	−55 to +90	60	90	30	350	75	5	50 at −10v, 850 at −50v	200	200K at −10v, 58K at −50v
1N126A	Miniature—60 volt (Note 2)	−55 to +90	60	90	30	350	75	5 (25 max.)	50 at −10v, 850 at −50v	200	200K at −10v, 58K at −50v
1N127	Miniature—100 volt	−55 to +90	100	90	30	300	125	3	25 at −10v, 300 at −50v	333	400K at −10v, 167K at −50v
1N127A	Miniature—100 volt (Note 2)	−55 to +90	100	90	30	300	125	3 (25 max.)	25 at −10v, 300 at −50v	333	400K at −10v, 167K at −50v
1N128	Miniature—High Back (Note 2)	−55 to +90	40	90	30	300	50	3	10 at −10v	333	1 meg. at −10v
1N191	Miniature—Computer	−55 to +90	90	90	30	300	—	5	Note 11 and Note 12	200	400 ohms (Note 11)
1N193	High Temperature	−50 to +150	40	50	30	100	Note 13	1.0 at +2v	20 at −10v, 40 at −40v (Note 14)	2000	500K at −10v, 125K at −50v
1N194	High Temperature	−50 to +150	40	50	30	100	Note 13	1.5 at +2v	10 at −40v (Note 12 and Note 14)	1333	400K at −10v
1N191A	High Temperature	−50 to +150	40	50	30	100	Note 13	1.5	10 at −40v (Note 12 and Note 14)	667	400K at −10v
1N195	High Temperature	−50 to +150	40	50	30	100	Note 13	2.0 at +2v	10 at −40v (Note 12 and Note 14)	1000	400K at −10v
1N196	High Temperature	−50 to +150	50	50	30	100	Note 13	1.0 at +2v	10 at −40v (Note 12 and Note 14)	2000	400K at −10v
1N198	Miniature—75°C	−55 to +90	80	90	30	300	100	4	10 at −10v, 50 at −50v (Note 15)	250	1 meg. at −10v and −50v
1N198A	Miniature—75°C (Note 2)	−55 to +90	80	90	30	300	100	4 (25 max.)	10 at −10v, 50 at −50v (Note 15)	250	1 meg. at −10v and −50v
1N355	High Back (Note 16)	−55 to +90	80	150	500	500	100	4	5 at −5v, 50 at −50v	250	1 meg. at −10v and −50v
1N417	Computer	−55 to +75	60	150	60	—	—	Note 20	Note 11 and Note 12	—	500K (Note 11)
		Note 17	Note 18	Note 19							
1N418	Computer	−55 to +75	60	45	16	100	—	7	Note 11 and Note 12	143	500K (Note 11)
		Note 17	Note 18								
1N419	Computer	−50 to +75	80	150	60	Note 21	—	125	Note 11 and Note 12	8	500K (Note 11)
		Note 17	Note 18	Note 21							
1N447	VLI (Very Low Impedance)	−55 to +75	30	200	60	500	75	25	20 at −10v, 60 at −30v	40	500K at −10v and −30v
1N448	VLI	−55 to +75	100	200	60	300	120	25	30 at −30v, 100 at −100v	40	1 meg. at −30v and −100v
1N449	VLI	−55 to +75	30	200	60	500	50	50	10 at −10v, 30 at −30v	20	1 meg. at −10v and −30v
1N450	VLI	−55 to +75	100	200	60	300	120	50	30 at −30v, 100 at −100v	20	1 meg. at −30v and −100v
1N451	VLI	−55 to +75	150	200	60	200	170	50	150 at −150v	20	1 meg. at −150v
1N452	VLI	−55 to +75	30	250	80	500	50	100	30 at −30v	10	1 meg. at −30v
1N453	VLI	−55 to +75	100	250	80	300	120	100	30 at −30v, 100 at −100v	10	1 meg. at −30v and −100v
1N454	VLI	−55 to +75	50	300	100	500	75	200	50 at −50v	5	1 meg. at −50v
1N455	VLI	−55 to +75	30	300	100	500	50	300	30 at −30v	5	1 meg. at −30v
1N631	Miniature—Computer	−50 to +75	60	150	60	—	—	Note 20	Note 11 and Note 12	—	500K (Note 11)
		Note 17		Note 19							
1N632	Miniature—Computer	−50 to +75	60	45	16	100	—	7	Note 11 and Note 12	143	500K (Note 11)
		Note 17									
1N633	Miniature—Computer	−50 to +75	80	150	60	Note 21	—	125	Note 11 and Note 12	8	500K (Note 11)
		Note 17		Note 21							
1N634	Miniature—VLI	−50 to +75	60	200	60	300	120	50	35 at −30v, 115 at −100v	20	850K at −30v and −100v
		Note 17									
1N635	Miniature—VLI	−50 to +75	60	200	60	200	170	50	175 at −150v	20	850K at −150v
		Note 17									
1N1093	Computer	−50 to +75	15	—	50	400	25	Note 22	25 at −5v and 75 at −15v at 55°C	8	200K at −5v and −15v at 55°C
		Note 17									

*Ratings are limiting values assigned by the manufacturer to operating or storage conditions (electrical, mechanical, or environmental) under the control of the user. If values are exceeded, permanent impairment of the device and/or performance may result.

Notes for Ratings and Characteristics Charts

Note 1: Units are matched in the forward direction at 1 volt so that the current flowing through the lower resistance unit is within 10% of that through the higher resistance unit. Ratings are shown for each diode.

Note 2: Available to military performance specifications.

Note 3: Consists of four specially selected and matched diodes whose resistances are balanced within ±2.5% in the forward direction at 1.5 volts. For additional balance, the forward resistance of each varistor pair is matched to within three ohms. Ratings shown are for each diode.

Note 4: Sixty cycle, resistance loaded half-wave rectifier service.

Note 5: Units are tested in a circuit employing an input of 1.6 volts rms at 40 MC, 75% modulated at 400 cycles. Demodulated output across a 4700 ohm resistor shunted by a 5 uuf capacitor is a minimum of 1.50 volts peak to peak.

Note 6: Minimum specified reverse resistance applies to all points between 0 and —10 volts with 60 cps sweep.

Note 7: Consists of four specially selected diodes whose forward currents are matched within a range of 1 ma. with 1 volt applied. Ratings shown are for each diode.

Note 8: For type 1N77A continuous operating voltage maximum is —50 volts and maximum power dissipation is 40 milliwatts.

Type	Recovery Current	Recovery Time
1N119	700 ua	0.5 usec
	87.5	3.5
1N120	700	0.5
	175	3.5
1N191	700	0.5
	87.5	3.5
1N193	400	0.5
1N194	300	0.2
1N194A	300	0.2
1N195	300	0.3
1N196	100	0.1
1N417*	500	0.3
1N418*	500	0.3
1N419*	500	0.3
1N571**	500	4.0
1N631*	500	0.3
1N632*	800	0.3
1N633*	1650	0.3

*Forward current = 5 ma, Reverse voltage = 40 ± 2v, Circuit resistance = 2000 ohms.

**Forward current = 100 ma. Reverse voltage = – 5v.

Note 13: If continuous reverse working voltage is exceeded, breakdown will occur at some higher value of the inverse voltage and suitable means must be provided to limit the current flow to less than 1 ma.

Note 14: At 150°C, maximum reverse currents are as follows:

1N193 = 200 ua at –10v, 500 ua at –50v
1N194 = 300 ua at –40v
1N194A = 300 ua at –40v
1N195 = 300 ua at –40v
1N196 = 300 ua at –40v

volts; light supplied at 2 lumens per sq. ft. having a color temperature of 2750 ± 100°K and interrupted at 200 to 400 cycles per second.

Note 10: Types 1N82 and 1N82A peak reverse voltage maximum rating is 5 volts and absolute maximum oscillator drive is 25 ma. These types are designed for operation as mixers up to 1000 megacycles and are capable of low noise operation as a mixer for UHF television in the 470-890 mc band. Overall noise selection limit for 1N82 is 16 db maximum and for 1N82A is 14 db maximum.

Note 11: Minimum specified resistance limit applies for all points as indicated below when the reverse characteristic is swept between 0 and −70 volts at 60 cycle rate,

Type 1N111	−20v to −50v	At 55°C
1N112	−10v to −50v	At 55°C
1N113	−10v to −50v	At 55°C
1N114	−10v to −50v	At 55°C
1N115	−10v to −50v	At 55°C
1N119	−20v to −50v	At 55°C
1N120	−20v to −50v	At 55°C
1N191	−10v to −50v	At 55°C
1N417	−10v to −60v	At 25°C
1N418	−10v to −60v	At 25°C
1N419	−20v to −90v*	At 25°C
1N631	−20v to −60v	At 25°C
1N632	−20v to −60v	At 25°C
1N633	−20v to −90v*	At 25°C

*For 0 to −100v sweep

Note 12: Reverse recovery time is specified and defined as the time required for the diode to recover to a specified reverse current when the operating coltage necessary to give 30 ma forward conduction is rapidly switched to −35 volts.

Note 16: Available as pairs, matched for forward conduction at −1.5 volts and dynamic impedance.

Note 17: Storage temperature as indicated, operating temperature range is +10 to +55°C.

Note 18: For 1N417 maximum reverse voltage pulse = 90 volts (1 sec. max.)
For 1N418 maximum reverse voltage pulse = 90 volts (1 sec. max.)
For 1N419 maximum reverse voltage pulse = 120 volts (1 sec. max.)

Note 19: For types 1N417 and 1N631, peak forward current = 150 ma at 20% duty cycle.

Note 20: For types 1N417 and 1N631, the forward voltage peak for a 50 ma current peak from a half sine wave of 0.1 usec pulse width and 100 kc pulse repetition frequency is 3.5 volts.

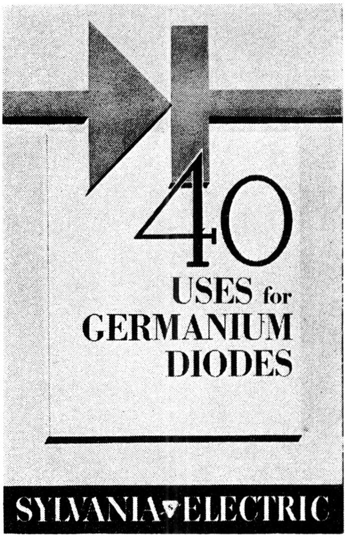
Note 21: For types 1N419 and 1N633, peak forward pulse = 150 ma for 2.0 usec pulse.

Note 22: For type 1N1093, the maximum forward voltage is 0.4 volts for a current of 5.0 ma at 25°C. At both 10°C and 50°C the forward characteristics are controlled at both 1.0 ma and 10.0 ma forward currents.

Note 23: Consists of four specially selected diodes whose forward current are matched within 6.5% of each other at 0.15 volts. All 1N435 varistors are within 12.5% of a nominal current at 0.15 volts. Ratings shown are for each diode.

Note 24: For type 1N571, maximum power dissipation is rated at 200 milliwatts.

40 USES FOR GERMANIUM DIODES



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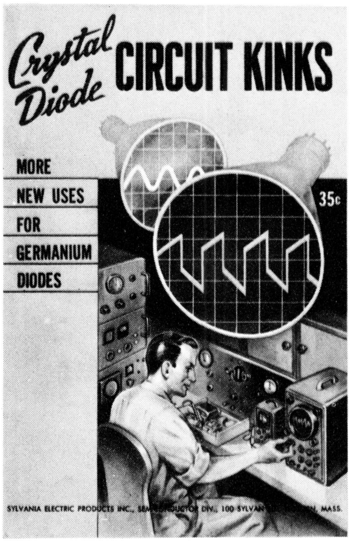

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Sylvania Crystal Diodes

*ABSOLUTE MAXIMUM RATINGS AT 25°C:

Sylvania Crystal Diodes

CHARACTERISTICS AT 25°C:

Type	Application or Description	Temperature Range °C	Continuous Reverse Working Voltage (volts)	Recurrent Peak Anode Current (ma)	Average Anode Current (ma)	Surge Current (ma/1 sec. max.)	Peak Reverse Voltage for Zero Dynamic Resistance (volts min.)	Forward Current at +1 Volt (ma min.)	Reverse Current (ua max.)	Forward Resistance at +1 Volt (ohms max.)	Reverse Resistance (ohms min.)
1N34A	60 volt	−50 to +90	60	50	50	500	70	5	30 at −10v, 500 at −50	200	333K at −10v, 100K at −50v
1N35	Matched Pair (Note 1)	−50 to +75	50	60	22.5	100	70	7	10 at −10v	143	1 meg. at −10v
1N38A	100 volt	−50 to +90	100	150	50	500	120	4	6 at −3v, 500 at −100v	250	500K at −3v, 200K at −100v
1N38B	100 volt (Note 2)	−50 to +90	100	150	50	500	120	4 (25 max.)	6 at −3v, 500 at −100v	250	500K at −3v, 200K at −100v
1N39A	200 volt	−50 to +90	200	150	50	500	225	4	100 at −100v, 600 at −200v	250	1 meg. at −100, 333K at −200v
1N40	Plug-in Varistor (Note 3)	−50 to +75	25	60	22.5	100	70	12.7 at 1.5v	40 at −10v	120	250K at −10v
1N41	Packaged Varistor (Note 3)	−50 to +75	25	60	22.5	100	70	12.7 at 1.5v	40 at −10v	120	250K at −10v
1N42	100 volt Varistor (Note 3)	−50 to +75	100	60	22.5	100	120	12.7 at 1.5v	750 at −100v	120	133K at −100v
1N54A	High Back Resistance	−50 to +90	50	150	50	500	70	5	7 at −10v, 100 at −50v	200	1.4 meg. at −10v, 500K at −100v
1N55A	150 volt (Note 2)	−50 to +90	150	150	50	500	165	4	500 at −150v	250	300K at −150v
1N56A	High Conduction (Note 2)	−50 to +90	40	200	60	1000	50	15	300 at −30v	67	100K at −30v
1N58A	100 volt	−50 to +90	100	150	50	500	115	4	600 at −100v	250	167K at −100v
1N59A	250 volt	−50 to +90	250	150	50	500	270	4	600 at −250v	333	200K at −150v
1N60	Video Detector	−50 to +90	25	150 Note 4	50 Note 4	500	—	Note 5	Note 6	—	150K (Note 6)
1N63	High Back Resistance	−55 to +90	100	150	50	500	120	4	50 at −50v	250	1 meg. at −50v
1N65	70 volt	−55 to +90	70	150	50	500	80	2.5	200 at −50v	400	250K at −50v
1N67A	Miniature—High Back (Note 2)	−55 to +90	80	90	30	300	100	4	5 at −5v, 50 at −50v	250	1 meg. at −5v and −50v
1N69	60 volt	−55 to +90	60	125	40	400	75	5	5 at −10v, 850 at −50v	200	333K at −10v, 100K at −50v
1N69A	60 volt (Note 2)	−55 to +90	60	125	40	400	75	5 (25 max.)	30 at −10v, 500 at −50v	200	333K at −10v, 100K at −50v*
1N70	100 volt	−55 to +90	100	90	30	350	125	3	25 at −10v, 300 at −50v	333	400K at −10v, 167K at −50v
1N70A	100 volt (Note 2)	−55 to +90	100	90	30	350	125	3 (25 max.)	25 at −10v, 300 at −50v	333	400K at −10v, 167K at −50v
1N71	Low Impedance Varistor (Note 7)	−50 to +75	40	200	60	1000	50	15	300 at −30v	67	100K at −30v
1N77A	Photodiode	0 to +50	Note 8	—	—	—	Note 9	—	15 at −10v, 100 at −50v (Dark)	—	670K at −10v, 500K at −50v
1N81	Low Voltage	−55 to +90	40	90	30	350	50	3	10 at −10v	333	1 meg. at −10v
1N81A	Low Voltage (Note 2)	−55 to +90	40	90	30	350	50	3 (25 max.)	10 at −10v	333	1 meg. at −10v
1N82	UHF Mixer	−50 to +90	Note 10	—	—	—	—	Note 10	—	—	—
1N82A	UHF Mixer	−50 to +90	Note 10	—	—	—	—	Note 10	—	—	—
1N90	Miniature—General Purpose	−55 to +90	60	90	30	300	75	5	750 at −50v	200	67K at −50v
1N98	Miniature—High Back	−55 to +90	80	90	30	300	100	20	8 at −5v, 100 at −50v	500	62.5K at −5v, 500K at −50v
1N100	Miniature—High Back	−55 to +90	80	90	30	300	100	20	5 at −5v, 50 at −50v	500	1 meg. at −5v and −50v
1N111	60 volt Computer	−50 to +90	60	150	25	500	70	5	Note 11	200	400K (Note 11)
1N112	60 volt Computer	−50 to +90	60	150	25	500	70	5	Note 11	200	200K (Note 11)
1N113	60 volt Computer	−50 to +90	60	150	25	500	70	2.5	Note 11	400	400K (Note 11)
1N114	60 volt Computer	−50 to +90	60	150	25	500	70	2.5	Note 11	400	200K (Note 11)
1N115	60 volt Computer	−50 to +90	60	150	25	500	70	2.5	Note 11	400	100K (Note 11)
1N118	Miniature—High Conduction	−55 to +90	60	30	90	250	75	20	100 at −50v	50	500K at −50v
1N119	60 volt—Computer	−50 to +90	60	150	25	500	70	5	Note 11 and Note 12	200	400K (Note 11)
1N120	60 volt—Computer	−50 to +90	60	150	25	500	70	5	Note 11 and Note 12	200	200K (Note 11)
1N126	Miniature—60 volt	−55 to +90	60	90	30	350	75	5	50 at −10v, 850 at −50v	200	200K at −10v, 58K at −50v
1N126A	Miniature—60 volt (Note 2)	−55 to +90	60	90	30	350	75	5 (25 max.)	50 at −10v, 850 at −50v	200	200K at −10v, 58K at −50v
1N127	Miniature—100 volt	−55 to +90	100	90	30	300	125	3	25 at −10v, 300 at −50v	333	400K at −10v, 167K at −50v
1N127A	Miniature—100 volt (Note 2)	−55 to +90	100	90	30	300	125	3 (25 max.)	25 at −10v, 300 at −50v	333	400K at −10v, 167K at −50v
1N128	Miniature—High Back (Note 2)	−55 to +90	40	90	30	300	50	3	10 at −10v	333	1 meg. at −10v
1N191	Miniature—Computer	−55 to +90	90	90	30	300	—	5	Note 11 and Note 12	200	400 ohms (Note 11)
1N193	High Temperature	−50 to +150	40	50	30	100	Note 13	1.0 at +2v	20 at −10v, 40 at −40v (Note 14)	2000	500K at −10v, 125K at −50v
1N194	High Temperature	−50 to +150	40	50	30	100	Note 13	1.5 at +2v	10 at −40v (Note 12 and Note 14)	1333	400K at −10v
1N191A	High Temperature	−50 to +150	40	50	30	100	Note 13	1.5	10 at −40v (Note 12 and Note 14)	667	400K at −10v
1N195	High Temperature	−50 to +150	40	50	30	100	Note 13	2.0 at +2v	10 at −40v (Note 12 and Note 14)	1000	400K at −10v
1N196	High Temperature	−50 to +150	50	50	30	100	Note 13	1.0 at +2v	10 at −40v (Note 12 and Note 14)	2000	400K at −10v
1N198	Miniature—75°C	−55 to +90	80	90	30	300	100	4	10 at −10v, 50 at −50v (Note 15)	250	1 meg. at −10v and −50v
1N198A	Miniature—75°C (Note 2)	−55 to +90	80	90	30	300	100	4 (25 max.)	10 at −10v, 50 at −50v (Note 15)	250	1 meg. at −10v and −50v
1N355	High Back (Note 16)	−55 to +90	80	150	500	500	100	4	5 at −5v, 50 at −50v	250	1 meg. at −10v and −50v
1N417	Computer	−55 to +75 Note 17	60 Note 18	150 Note 19	60	—	—	Note 20	Note 11 and Note 12	—	500K (Note 11)
1N418	Computer	−55 to +75 Note 17	60 Note 18	45	16	100	—	7	Note 11 and Note 12	143	500K (Note 11)
1N419	Computer	−50 to +75 Note 17	80 Note 18	150 Note 21	60	Note 21	—	125	Note 11 and Note 12	8	500K (Note 11)
1N447	VLI (Very Low Impedance)	−55 to +75	30	200	60	500	75	25	20 at −10v, 60 at −30v	40	500K at −10v and −30v
1N448	VLI	−55 to +75	100	200	60	300	120	25	30 at −30v, 100 at −100v	40	1 meg. at −30v and −100v
1N449	VLI	−55 to +75	30	200	60	500	50	50	10 at −10v, 30 at −30v	20	1 meg. at −10v and −30v
1N450	VLI	−55 to +75	100	200	60	300	120	50	30 at −30v, 100 at −100v	20	1 meg. at −30v and −100v
1N451	VLI	−55 to +75	150	200	60	200	170	50	150 at −150v	20	1 meg. at −150v
1N452	VLI	−55 to +75	30	250	80	500	50	100	30 at −30v	10	1 meg. at −30v
1N453	VLI	−55 to +75	100	250	80	300	120	100	30 at −30v, 100 at −100v	10	1 meg. at −30v and −100v
1N454	VLI	−55 to +75	50	300	100	500	75	200	50 at −50v	5	1 meg. at −50v
1N455	VLI	−55 to +75	30	300	100	500	50	300	30 at −30v	5	1 meg. at −30v
1N631	Miniature—Computer	−50 to +75 Note 17	60	150 Note 19	60	—	—	Note 20	Note 11 and Note 12	—	500K (Note 11)
1N632	Miniature—Computer	−50 to +75 Note 17	60	45	16	100	—	7	Note 11 and Note 12	143	500K (Note 11)
1N633	Miniature—Computer	−50 to +75 Note 17	80	150 Note 21	60	Note 21	—	125	Note 11 and Note 12	8	500K (Note 11)
1N634	Miniature—VLI	−50 to +75 Note 17	60	200	60	300	120	50	35 at −30v, 115 at −100v	20	850K at −30v and −100v
1N635	Miniature—VLI	−50 to +75 Note 17	60	200	60	200	170	50	175 at −150v	20	850K at −150v
1N1093	Computer	−50 to +75 Note 17	15	—	50	400	25	Note 22	25 at −5v and 75 at −15v at 55°C	8	200K at −5v and −15v at 55°C

*Ratings are limiting values assigned by the manufacturer to operating or storage conditions (electrical, mechanical, or environmental) under the control of the user. If values are exceeded, permanent impairment of the devic and/or performance may result.

Sylvania Crystal Diodes

***ABSOLUTE MAXIMUM RATINGS AT 25°C:**

Sylvania Crystal Diodes

CHARACTERISTICS AT 25°C:

Type	Application or Description	Temperature Range °C	Continuous Reverse Working Voltage (volts)	Recurrent Peak Anode Current (ma)	Average Anode Current (ma)	Surge Current (ma/1 sec. max.)	Peak Reverse Voltage for Zero Dynamic Resistance (volts min.)	Forward Current at +1 Volt (ma min.)	Reverse Current (ua max.)	Forward Resistance at +1 Volt (ohms max.)	Reverse Resistance (ohms min.)
1N34A	60 volt	−50 to +90	60	50	50	500	70	5	30 at −10v, 500 at −50	200	333K at −10v, 100K at −50v
1N35	Matched Pair (Note 1)	−50 to +75	50	60	22.5	100	70	7	10 at −10v	143	1 meg. at −10v
1N38A	100 volt	−50 to +90	100	150	50	500	120	4	6 at −3v, 500 at −100v	250	500K at −3v, 200K at −100v
1N38B	100 volt (Note 2)	−50 to +90	100	150	50	500	120	4 (25 max.)	6 at −3v, 500 at −100v	250	500K at −3v, 200K at −100v
1N39A	200 volt	−50 to +90	200	150	50	500	225	4	100 at −100v, 600 at −200v	250	1 meg. at −100, 333K at −200v
1N40	Plug-in Varistor (Note 3)	−50 to +75	25	60	22.5	100	70	12.7 at 1.5v	40 at −10v	120	250K at −10v
1N41	Packaged Varistor (Note 3)	−50 to +75	25	60	22.5	100	70	12.7 at 1.5v	40 at −10v	120	250K at −10v
1N42 43	100 volt Varistor (Note 3)	−50 to +75	100	60	22.5	100	120	12.7 at 1.5v	750 at −100v	120	133K at −100v
1N54A	High Back Resistance	−50 to +90	50	150	50	500	70	5	7 at −10v, 100 at −50v	200	1.4 meg. at −10v, 500K at −100v
1N55A	150 volt (Note 2)	−50 to +90	150	150	50	500	165	4	500 at −150v	250	300K at −150v
1N56A	High Conduction (Note 2)	−50 to +90	40	200	60	1000	50	15	300 at −30v	67	100K at −30v
1N58A	100 volt	−50 to +90	100	150	50	500	115	4	600 at −100v	250	167K at −100v
1N59A	250 volt	−50 to +90	250	150	50	500	270	4	600 at −250v	333	200K at −150v
1N60	Video Detector	−50 to +90	25	150 Note 4	50 Note 4	500	—	Note 5	Note 6	—	150K (Note 6)
1N63	High Back Resistance	−55 to +90	100	150	50	500	120	4	50 at −50v	250	1 meg. at −50v
1N65	70 volt	−55 to +90	70	150	50	500	80	2.5	200 at −50v	400	250K at −50v
1N67A	Miniature—High Back (Note 2)	−55 to +90	80	90	30	300	100	4	5 at −5v, 50 at −50v	250	1 meg. at −5v and −50v
1N69	60 volt	−55 to +90	60	125	40	400	75	5	5 at −10v, 850 at −50v	200	333K at −10v, 100K at −50v
1N69A	60 volt (Note 2)	−55 to +90	60	125	40	400	75	5 (25 max.)	30 at −10v, 500 at −50v	200	333K at −10v, 100K at −50v*
1N70	100 volt	−55 to +90	100	90	30	350	125	3	25 at −10v, 300 at −50v	333	400K at −10v, 167K at −50v
1N70A	100 volt (Note 2)	−55 to +90	100	90	30	350	125	3 (25 max.)	25 at −10v, 300 at −50v	333	400K at −10v, 167K at −50v
1N71 72	Low Impedance Varistor (Note 7)	−50 to +75	40	200	60	1000	50	15	300 at −30v	67	100K at −30v
1N77A	Photodiode	0 to +50	Note 8	—	—	—	Note 9	—	15 at −10v, 100 at −50v (Dark)	—	670K at −10v, 500K at −50v
1N81	Low Voltage	−55 to +90	40	90	30	350	50	3	10 at −10v	333	1 meg. at −10v
1N81A	Low Voltage (Note 2)	−55 to +90	40	90	30	350	50	3 (25 max.)	10 at −10v	333	1 meg. at −10v
1N82	UHF Mixer	−50 to +90	Note 10	—	—	—	—	Note 10	—	—	—
1N82A	UHF Mixer	−50 to +90	Note 10	—	—	—	—	Note 10	—	—	—
1N90	Miniature—General Purpose	−55 to +90	60	90	30	300	75	5	750 at −50v	200	67K at −50v
1N98	Miniature—High Back	−55 to +90	80	90	30	300	100	20	8 at −5v, 100 at −50v	500	62.5K at −5v, 500K at −50v
1N100	Miniature—High Back	−55 to +90	80	90	30	300	100	20	5 at −5v, 50 at −50v	500	1 meg. at −5v and −50v
1N111	60 volt Computer	−50 to +90	60	150	25	500	70	5	Note 11	200	400K (Note 11)
1N112	60 volt Computer	−50 to +90	60	150	25	500	70	5	Note 11	200	200K (Note 11)
1N113	60 volt Computer	−50 to +90	60	150	25	500	70	2.5	Note 11	400	400K (Note 11)
1N114	60 volt Computer	−50 to +90	60	150	25	500	70	2.5	Note 11	400	200K (Note 11)
1N115	60 volt Computer	−50 to +90	60	150	25	500	70	2.5	Note 11	400	100K (Note 11)
1N118	Miniature—High Conduction	−55 to +90	60	30	90	250	75	20	100 at −50v	50	500K at −50v
1N119	60 volt—Computer	−50 to +90	60	150	25	500	70	5	Note 11 and Note 12	200	400K (Note 11)
1N120	60 volt—Computer	−50 to +90	60	150	25	500	70	5	Note 11 and Note 12	200	200K (Note 11)
1N126	Miniature—60 volt	−55 to +90	60	90	30	350	75	5	50 at −10v, 850 at −50v	200	200K at −10v, 58K at −50v
1N126A	Miniature—60 volt (Note 2)	−55 to +90	60	90	30	350	75	5 (25 max.)	50 at −10v, 850 at −50v	200	200K at −10v, 58K at −50v
1N127	Miniature—100 volt	−55 to +90	100	90	30	300	125	3	25 at −10v, 300 at −50v	333	400K at −10v, 167K at −50v
1N127A	Miniature—100 volt (Note 2)	−55 to +90	100	90	30	300	125	3 (25 max.)	25 at −10v, 300 at −50v	333	400K at −10v, 167K at −50v
1N128	Miniature—High Back (Note 2)	−55 to +90	40	90	30	300	50	3	10 at −10v	333	1 meg. at −10v
1N191 137	Miniature—Computer	−55 to +90	90	90	30	300	—	5	Note 11 and Note 12	200	400 ohms (Note 11)
1N193	High Temperature	−50 to +150	40	50	30	100	Note 13	1.0 at +2v	20 at −10v, 40 at −40v (Note 14)	2000	500K at −10v, 125K at −50v
1N194	High Temperature	−50 to +150	40	50	30	100	Note 13	1.5 at +2v	10 at −40v (Note 12 and Note 14)	1333	400K at −10v
1N194A	High Temperature	−50 to +150	40	50	30	100	Note 13	1.5	10 at −40v (Note 12 and Note 14)	667	400K at −10v
1N195	High Temperature	−50 to +150	40	50	30	100	Note 13	2.0 at +2v	10 at −40v (Note 12 and Note 14)	1000	400K at −10v
1N196	High Temperature	−50 to +150	50	50	30	100	Note 13	1.0 at +2v	10 at −40v (Note 12 and Note 14)	2000	400K at −10v
1N198	Miniature—75°C	−55 to +90	80	90	30	300	100	4	10 at −10v, 50 at −50v (Note 15)	250	1 meg. at −10v and −50v
1N198A	Miniature—75°C (Note 2)	−55 to +90	80	90	30	300	100	4 (25 max.)	10 at −10v, 50 at −50v (Note 15)	250	1 meg. at −10v and −50v
1N355	High Back (Note 16)	−55 to +90	80	150	500	500	100	4	5 at −5v, 50 at −50v	250	1 meg. at −10v and −50v
1N417	Computer	−55 to +75 Note 17	60 Note 18	150 Note 19	60	—	—	Note 20	Note 11 and Note 12	—	500K (Note 11)
1N418	Computer	−55 to +75 Note 17	60 Note 18	45	16	100	—	7	Note 11 and Note 12	143	500K (Note 11)
1N419	Computer	−50 to +75 Note 17	80 Note 18	150 Note 21	60	Note 21	—	125	Note 11 and Note 12	8	500K (Note 11)
1N447	VLI (Very Low Impedance)	−55 to +75	30	200	60	500	75	25	20 at −10v, 60 at −30v	40	500K at −10v and −30v
1N448	VLI	−55 to +75	100	200	60	300	120	25	30 at −30v, 100 at −100v	40	1 meg. at −30v and −100v
1N449	VLI	−55 to +75	30	200	60	500	50	50	10 at −10v, 30 at −30v	20	1 meg. at −10v and −30v
1N450	VLI	−55 to +75	100	200	60	300	120	50	30 at −30v, 100 at −100v	20	1 meg. at −30v and −100v
1N451	VLI	−55 to +75	150	200	60	200	170	50	150 at −150v	20	1 meg. at −150v
1N452	VLI	−55 to +75	30	250	80	500	50	100	30 at −30v	10	1 meg. at −30v
1N453	VLI	−55 to +75	100	250	80	300	120	100	30 at −30v, 100 at −100v	10	1 meg. at −30v and −100v
1N454	VLI	−55 to +75	50	300	100	500	75	200	50 at −50v	5	1 meg. at −50v
1N455 457	VLI	−55 to +75	30	300	100	500	50	300	30 at −30v	5	1 meg. at −30v
1N631 408	Miniature—Computer	−50 to +75 Note 17	60	150 Note 19	60	—	—	Note 20	Note 11 and Note 12	—	500K (Note 11)
1N632	Miniature—Computer	−50 to +75 Note 17	60	45	16	100	—	7	Note 11 and Note 12	143	500K (Note 11)
1N633	Miniature—Computer	−50 to +75 Note 17	80	150 Note 21	60	Note 21	—	125	Note 11 and Note 12	8	500K (Note 11)
1N634	Miniature—VLI	−50 to +75 Note 17	60	200	60	300	120	50	35 at −30v, 115 at −100v	20	850K at −30v and −100v
1N635	Miniature—VLI	−50 to +75 Note 17	60	200	60	200	170	50	175 at −150v	20	850K at −150v
1N1093	Computer	−50 to +75 Note 17	15	—	50	400	25	Note 22	25 at −5v and 75 at −15v at 55°C	8	200K at −5v and −15v at 55°C

*Ratings are limiting values assigned by the manufacturer to operating or storage conditions (electrical, mechanical, or environmental) under the control of the user. If values are exceeded, permanent impairment of the device and/or performance may result.

Notes for Ratings and Characteristics Charts

Note 1: Units are matched in the forward direction at 1 volt so that the current flowing through the lower resistance unit is within 10% of that through the higher resistance unit. Ratings are shown for each diode.

Note 2: Available to military performance specifications.

Note 3: Consists of four specially selected and matched diodes whose resistances are balanced within ±2.5% in the forward direction at 1.5 volts. For additional balance, the forward resistance of each varistor pair is matched to within three ohms. Ratings shown are for each diode.

Note 4: Sixty cycle, resistance loaded half-wave rectifier service.

Note 5: Units are tested in a circuit employing an input of 1.6 volts rms at 40 MC, 75% modulated at 400 cycles. Demodulated output across a 4700 ohm resistor shunted by a 5 uuf capacitor is a minimum of 1.50 volts peak to peak.

Note 6: Minimum specified reverse resistance applies to all points between 0 and —10 volts with 60 cps sweep.

Note 7: Consists of four specially selected diodes whose forward currents are matched within a range of 1 ma. with 1 volt applied. Ratings shown are for each diode.

Note 8: For type 1N77A continuous operating voltage maximum is —50 volts and maximum power dissipation is 40 milliwatts.

Note 9: Light sensitivity = 16 to 40 volts peak to peak across 100K ohms in series with the photodiode and a reverse supply voltage of 45 volts; light supplied at 2 lumens per sq. ft. having a color temperature of 2750 ± 100°K and interrupted at 200 to 400 cycles per second.

Note 10: Types 1N82 and 1N82A peak reverse voltage maximum rating is 5 volts and absolute maximum oscillator drive is 25 ma. These types are designed for operation as mixers up to 1000 megacycles and are capable of low noise operation as a mixer for UHF television in the 470-890 mc band. Overall noise selection limit for 1N82 is 16 db maximum and for 1N82A is 14 db maximum.

Note 11: Minimum specified resistance limit applies for all points as indicated below when the reverse characteristic is swept between 0 and –70 volts at 60 cycle rate,

Type			
1N111	–20v to	–50v	At 55°C
1N112	–10v to	–50v	At 55°C
1N113	–10v to	–50v	At 55°C
1N114	–10v to	–50v	At 55°C
1N115	–10v to	–50v	At 55°C
1N119	–20v to	–50v	At 55°C
1N120	–20v to	–50v	At 55°C
1N191	–10v to	–50v	At 55°C
1N417	–10v to	–60v	At 25°C
1N418	–10v to	–60v	At 25°C
1N419	–20v to	–90v*	At 25°C
1N631	–20v to	–60v	At 25°C
1N632	–20v to	–60v	At 25°C
1N633	–20v to	–90v*	At 25°C

*For 0 to –100v sweep

Note 12: Reverse recovery time is specified and defined as the time required for the diode to recover to a specified reverse current when the operating coltage necessary to give 30 ma forward conduction is rapidly switched to –35 volts.

Type	Recovery Current	Recovery Time
1N119	700 ua	0.5 usec
	87.5	3.5
1N120	700	0.5
	175	3.5
1N191	700	0.5
	87.5	3.5
1N193	400	0.5
1N194	300	0.2
1N194A	300	0.2
1N195	300	0.3
1N196	100	0.1
1N417*	500	0.3
1N418*	500	0.3
1N419*	500	0.3
1N571**	500	4.0
1N631*	500	0.3
1N632*	800	0.3
1N633*	1650	0.3

*Forward current = 5 ma, Reverse voltage = 40 ± 2v, Circuit resistance = 2000 ohms.

**Forward current = 100 ma. Reverse voltage = – 5v.

Note 13: If continuous reverse working voltage is exceeded, breakdown will occur at some higher value of the inverse voltage and suitable means must be provided to limit the current flow to less than 1 ma.

Note 14: At 150°C, maximum reverse currents are as follows:

1N193 = 200 ua at –10v, 500 ua at –50v
1N194 = 300 ua at –40v
1N194A = 300 ua at –40v
1N195 = 300 ua at –40v
1N196 = 300 ua at –40v

Note 15: For type 1N198A at 75°C, the maximum reverse current at –10 volts is 75 ua and at –50 volts is 250 ua. Also at 75°C, the forward current at 1 volt is 5 to 35 ma.

Note 16: Available as pairs, matched for forward conduction at –1.5 volts and dynamic impedance.

Note 17: Storage temperature as indicated, operating temperature range is +10 to +55°C.

Note 18: For 1N417 maximum reverse voltage pulse = 90 volts (1 sec. max.)
For 1N418 maximum reverse voltage pulse = 90 volts (1 sec. max.)
For 1N419 maximum reverse voltage pulse = 120 volts (1 sec. max.)

Note 19: For types 1N417 and 1N631, peak forward current = 150 ma at 20% duty cycle.

Note 20: For types 1N417 and 1N631, the forward voltage peak for a 50 ma current peak from a half sine wave of 0.1 usec pulse width and 100 kc pulse repetition frequency is 3.5 volts.

Note 21: For types 1N419 and 1N633, peak forward pulse = 150 ma for 2.0 usec pulse.

Note 22: For type 1N1093, the maximum forward voltage is 0.4 volts for a current of 5.0 ma at 25°C. At both 10°C and 50°C the forward characteristics are controlled at both 1.0 ma and 10.0 ma forward currents.

Note 23: Consists of four specially selected diodes whose forward current are matched within 6.5% of each other at 0.15 volts. All 1N435 varistors are within 12.5% of a nominal current at 0.15 volts. Ratings shown are for each diode.

Note 24: For type 1N571, maximum power dissipation is rated at 200 milliwatts.